Shaft Seals

A self-study guide for improved technician knowledge and fleet efficiency

TFO
TROUBLE-FREE OPERATION

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INTRODUCTION

This book, produced for use by SKF distributors and customers, should prove of practical value to engineers, fleet mechanics, maintenance superintendents and anyone who can benefit from a thorough understanding of seals. It will explain:

- How to select the best seal for any given application;
- How to improve performance with proper installation;
- How to spot – and correct – seal problems with the least possible amount of time and money.

How to Use this Study Guide

This self-study guide is programmed to increase performance productivity. Each chapter consists of a logical organization of material, technical diagrams and a short quiz to help you retain what you study.

Start by carefully reading the text portion of each chapter. Make notes or underline if you wish; this can help you remember what you've read.

It does not matter whether you are a fast or slow learner. At the end of the program, you will have learned the same information – and should retain it – as well as any other "student."

The chapter quizzes are an important phase in self-study learning since they are intended to reinforce the material covered. The quiz questions are straightforward multiple choice and true-false. There are no "trick questions." Your answers can easily be checked within the context of the chapter.

Complete each review in order before going on to the next chapter. If you are not sure of an answer to a question, check back in the chapter and review that portion again.

CHAPTER 1
GENERAL SEALING

Brief History of the Shaft Seal and Scotseals

General Sealing Technology

Radial shaft seals perform one and only one function – an important one. They protect bearings serving as a barrier. Bearings are necessary to reduce friction between an object and the surface over which it is moved. Bearings need to be continuously lubricated, and bearing life declines rapidly in the absence of lubrication.

The seal plays a vital role in the bearing life as Henry Ford discovered with the Model T. The greased wheels did not have an adequate system to retain grease and it was flung out as the wheels rotated creating a very dirty environment around the wheel and deprived the bearing of lubrication. In 1926 SKF, then Chicago Rawhide, provided an industry changing product, the oil seal, coined "The Perfect Oil Seal".

The radial shaft seals are designed to:

- Retain lubricants or fluids
- Exclude contamination
- Confine pressure
- Separate fluids

Seals are necessary for sealing in lubricants that are needed to protect the bearings and to seal out dirt, water and other contaminants.

Seal designs and materials are constantly being developed, tested and improved. The testing is being done to conform with today's increased performance and durability requirements.

In the Heavy Truck and Bus market, seal design and material will consider the application in which it is to be placed including the lubrication media, seal location, external environment and the operating condition. There are three categories of shaft seals used in the truck and bus market.

Grease Seals

Greases have a relatively high viscosity and are thus relatively easy to retain in the bearing arrangement. The grease seal design usually includes a fairly lightly loaded spring. Grease seals located on a truck or bus would also require the ability to exclude contaminants, including dirt and water incorporating radial and/or axial dirt lips.

Oil Seals

Lubricating oils, particularly relatively low-viscosity oils, are much more difficult to retain in a bearing arrangement than greases. The seal design and material will be critical to oil retention. Therefore, spring loaded radial shaft seals are used almost exclusively. For instance, the patented Waveseal® lip has a sinusoidally formed lip edge which produces a pumping action to the inside as well as outside irrespective of rotation direction. Exclusion is often an important factor for oil seals, and radial and axial dirt lips designed to exclude dirt and water are incorporated as well.

Scotseals

SKF introduced Scotseals in the mid 1960's as truck wheel lubrication moved from grease to oil bath. The radial shaft seals used at that time did not adequately retain the new oils used to lubricate the bearings. Then SKF changed the industry again with the Scotseal (Self Contained Oil Type), a unitized seal design that retained the oil lubrication in the bearings and excluded water and dirt road contaminants.

Sealing Materials

Seal design is only part of the solution. Seals are manufactured from a wide variety of elastomers determined by the operating conditions. The elastomers used by SKF in heavy truck include Nitriles, Hydrogenated Nitrile and Viton. The temperature and wear capabilities for each are listed below.

Operating Temperatures:

The operating temperature capabilities for each of these materials are listed to the right (fig. 1A & 1B).

Wear Resistance:

The wear resistance capabilities for each of these are listed to the right (fig. 2).

Chemical Resistance:

The chemical resistance of the seal material is an important factor to be considered when selecting a seal, particularly with today's harsh synthetic fluids used in heavy truck and bus wheel ends. The chemical resistance of seals is also influenced by temperature as well as pressure and the amount of media present. Because of the complex relationships existing between the individual factors, it is not possible to give universally valid data regarding the chemical resistance of a particular material. However, the Scotseal PlusXL and Scotseal Longlife are designed with a specially formulated HNBR to be compatible with today's harsh wheel end synthetic fluids.

Heavy Truck Seals

Seals are found in many locations on a truck or bus. (fig. 3) The kind of seal depends on the location and function of the seal. The diagram below lists the many places seals are located on tractors, trucks, buses and trailers. Today, most wheel ends are oil bath lubricated and use SKF's Scotseal.

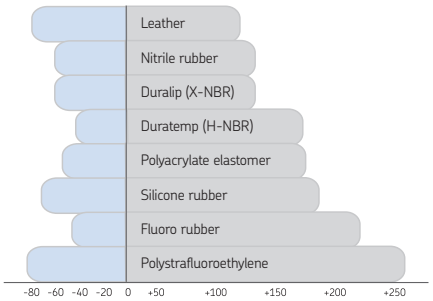


fig. 1A Temperature °C

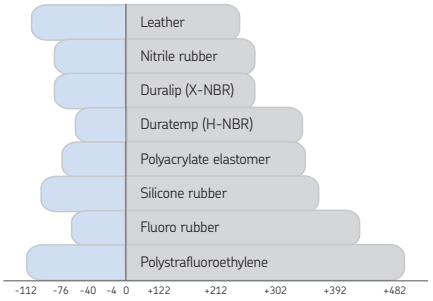


fig. 1B Temperature °F

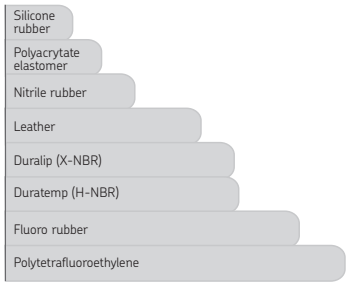
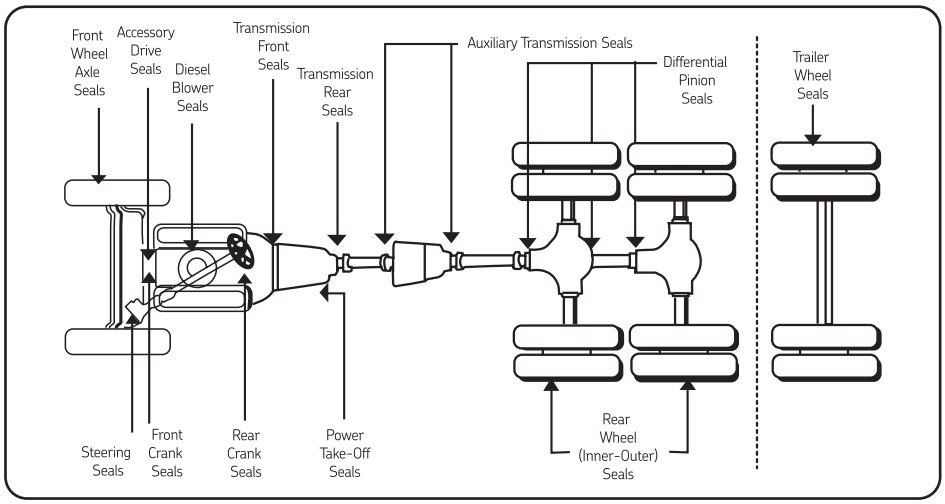


fig. 2 Wear resistance



This diagram shows the location of seals most often replaced in tractors, trucks, trailers and buses. Wheel or axle seals are most often bath lubrication systems using Scotseals (fig. 3).

CHAPTER 2
SHAFT SEALS

In this world of moving parts, whenever a shaft rotates, it needs a bearing for smooth, effective operation.

In most cases, where there's a bearing, you'll find a seal helping it to do its job better. In simple terms, a shaft seal is a barrier.

Shaft seals are designed to:

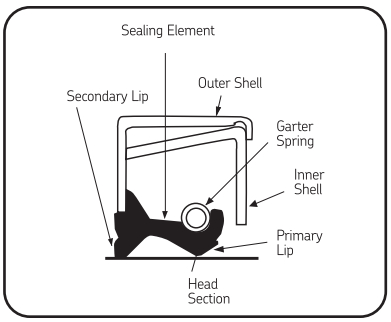
- Retain lubricants or liquids
- Confine pressure
- Exclude dirt
- Separate fluids

Seals are necessary for sealing in lubricants that are needed to protect the bearings and to seal out dirt, water and contaminants. To do both jobs effectively, all seals demand precise engineering and manufacturing.

Seal designs and materials are constantly being developed, tested and improved. This testing is being done to conform with today's increased performance and durability requirements.

The media being sealed can be anything from light oil to heavy grease, or even hot turbine gases. Wheel seals are among the most common applications. However, in the case of wheel seals, the shaft remains stationary and the wheel hub rotates. The seal retains lube in the bearing, and at the same time, protects the bearing from contaminants such as water, dirt, dust and abrasives.

First, it must be decided which is more important: retention of lubricant, exclusion of foreign matter or, in some cases, both.



(fig. 1).

Seal Design

The shaft seal is a small and simple looking product with a big and important job. The following describes a typical seal and the function of each of its components (fig. 1). Scotseals will be covered in the next chapter. (Page 11)

Seal Components

1. **Outer Shell (Case).** The outer, cup-shaped, rigid structure of the lip seal assembly acts as a protective cover for the head of the sealing element and more importantly holds the installed seal in place.

2. **Inner Shell (Case).** A rigid cup-shaped component of a seal assembly which is placed inside the outer seal case. It can function as a reinforcing member, shield, spring retainer or lip-clamping device.
3. **Sealing Element.** The flexible elastomeric "working" component of a lip seal assembly which rides against the shaft.
4. **Primary Lip.** The flexible, spring-loaded elastomeric lip component of the sealing element which contacts the rotating surface.
5. **Secondary Lip (Auxiliary Lip).** A short, non-spring-loaded lip of the sealing element which is located at the outside seal face of a radial lip seal. It is used to exclude contaminants.
6. **Garter Spring.** A coiled wire spring with its ends connected. It is used for maintaining a sealing force between the sealing element and sealing surface.

How The Seal Works

The following is a review of how the seal components work together to retain lubricants, confine pressure, exclude contaminants and separate liquids.

Retention Seals

Seals designed to retain lubricants or keep normal operating pressure in the bearing cavity are known as retention seals.

Retention seals (normally spring-loaded) are not recommended for more than light dirt exclusion. Because of their specific function, they rarely face toward dirt or heavy contaminants.

Exclusion Seals

These seals prevent dirt, water and contaminants from entering the bearing assembly. There is a wide variety of exclusion seals. Some have a single lip and no spring reinforcement. With others, the lip action is at the outside diameter of the seal. Still others were created especially for mud applications.

Exclusion seals, with lips pointing outward, can be kept lubricated and clear of dirt by purging (forcing grease through them).

Retention/Exclusion

Many applications require the seal to perform both the retention and exclusion functions at the same time. For example, the seal may need to confine a lubricant, as well as exclude road dust, mud, water, or other highway contaminants.

For applications that require both lube retention and dirt exclusion, a special type of protection is needed, either a combination of two seals, or dual sealing elements within one assembly.

The kind of seal (grease vs. oil bath, for example) depends on the location and function of the seal.

Wheel or axle seals are either grease seals or oil bath seals (Scotseal-Self Contained Oil Type Seals).

CHAPTER 2 REVIEW

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any of the questions. This learning technique assures more than four times the normal retention rate for even this technical subject.

1. A shaft seal is a barrier designed to _____.
   - ❑ a. retain lubricants or liquids and exclude dirt
   - ❑ b. confine pressure
   - ❑ c. separate fluids
   - ❑ d. all of the above

1. D

2. A typical vehicle may require _____.
   - ❑ a. steering seals
   - ❑ b. transmission rear seals
   - ❑ c. front crank seals
   - ❑ d. all of the above

2. D

3. Another name for the outer shell of the seal is the outer _____.
   - ❑ a. lip
   - ❑ b. case
   - ❑ c. cone
   - ❑ d. spring

3. B

4. Every rotating shaft requires a bearing and a seal for smooth, effective operation.
   - ❑ True ❑ False

4. T

5 A shaft seal is a barrier designed only to confine pressure.
   - ❑ True ❑ False

5. F

6. Seals are needed to seal in lubricants necessary for the bearings, and to seal out dirt, water, and contaminants.
   ❏ True ❏ False

6. T

7. If the seal's basic job is to retain lubricants or liquid, the seal lip must face toward the lubricant or pressure being retained.
   ❏ True ❏ False

7. T

8. If the seal's basic job is to exclude contaminants, the lip of the seal should face toward the bearing, instead of toward the contaminants.
   ❏ True ❏ False

8. F

9. Spring-loaded seals designed to retain lubricants or keep pressure in the bearing cavity are known as exclusion seals.
   ❏ True ❏ False

9. F

10. Retention seals stop dirt, water, and contaminants from entering the bearing cavity.
    ❏ True ❏ False

10. F

11. Seal components include an outer shell, inner shell, sealing element, primary lip and garter spring.
    ❏ True ❏ False

11. T

CHAPTER 3
SCOTSEALS

The Scotseal system

In addition to the standard line of grease seals, SKF has designed a complete oil bath sealing system, Scotseal, for trailer wheels, tractor front and drive wheels, and bus wheels.

Wheel ends go from grease to oil

In the late 1950's, the trucking industry began to bathe wheel bearings in oil instead of packing them in grease. But those early designs had a problem: the sealing element was pressed into the wheel. It turned with the wheel. At high speeds, centrifugal force would lift the sealing lip off the axle – allowing oil to leak.

The solution was to use extra stiff leather with a heavy tension spring to combat centrifugal force. But this added pressure wore grooves in the axle.

So, a special ring was pressed over the axle. For years, this early design was the only one available. Then, SKF introduced the Self Contained Oil Type Seal – Scotseal, now known as Scotseal Classic (fig. 1).

The chance of axle damage from the seal and the effect of centrifugal force on the sealing element are both reduced to zero.

Early oil seals had only one leather sealing lip. That single lip had to perform the dual function of sealing oil in and sealing dirt out. Later designs offered a special axle ring to assist in blocking dirt. But still, they had just one sealing point.

Scotseal's design eliminates the problem by incorporating a heavy-duty dirt lip and a secondary dirt lip in addition to the sealing lip. The design is so efficient it will seal out dust, dirt, water and salt.

Scotseal Classic design (fig. 1).

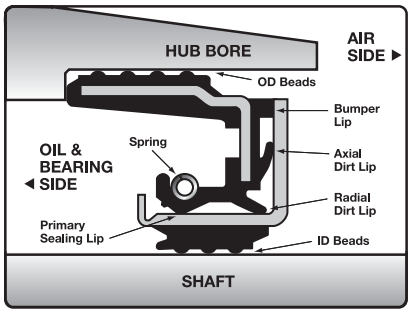
Scotseal® Family of Wheel Seals

The Scotseal family of seals features three product variations that are suited to your particular preference, application and environment. The entire Scotseal family offers you the right sealing solution for every kind of wheel end maintenance. The brand recognition, along with the outstanding quality and value, insures that you are installing the optimum seal for your operation.

The Scotseal Classic has become the trucking industry standard and best value for more than 30 years. The Scotseal Longlife provides you with an extended life seal with superior tolerance to higher wheel end temperatures, and is compatible with synthetic lubricants. The Scotseal PlusXL provides you with an extended life seal with superior tolerance to higher wheel end temperatures, and is compatible with synthetic lubricants.

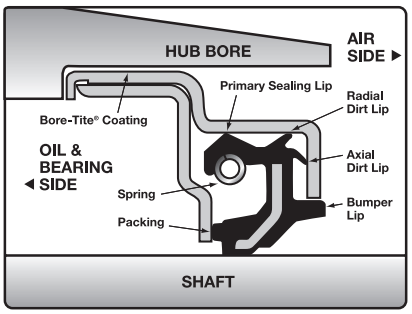
Scotseal Construction

Scotseal® *PlusXL* is a rubber unitized, one piece design. The Scotseal PlusXL consists of four sealing lips; a spring loaded primary sealing lip with patented Waveseal® design that is factory pre-lubed, a radial and axial dirt lip, plus an outer bumper lip that acts as a preliminary dirt excluder. Scotseal PlusXL requires no special installation tools and maintains a rubber-to-metal contact between the seal O.D. and the hub bore surface as well as a rubber-to-metal contact between the packing I.D. and spindle. (See fig. 2).



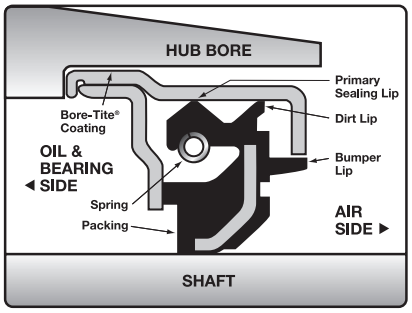
Scotseal® *PlusXL*
(fig. 2).

Scotseal® *Longlife* is a unitized, one piece design consisting of a sealing element (packing) that is assembled between a metal outer and inner case. The Scotseal Longlife's packing consists of four sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed, a radial and axial dirt lip, plus an outer bumper lip that acts as a preliminary dirt excluder. The Scotseal Longlife is pressfit into the hub bore using Scotseal Installation Tools. The Scotseal Longlife maintains a metal-to-metal contact between the seal O.D. and the hub bore surface as well as a metal-to-metal contact between the packing I.D. and the spindle. (See fig. 3).



Scotseal® *Longlife*
(fig. 3).

Scotseal® *Classic* is a unitized, one piece design consisting of a sealing element (packing) that is assembled between a metal outer and inner case. The packing consists of three sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed, a dirt exclusion lip, and an outer bumper lip that acts as a preliminary dirt excluder. The seal is pressfit into the hub bore using Scotseal Installation Tools. The Scotseal Classic maintains a metal-to-metal contact between the seal O.D. and the hub bore surface as well as a metal-to-metal contact between the packing I.D. and the spindle. (See fig. 4).



Scotseal® *Classic* (fig. 4).

A Scotseal® for Every Application

With the dated two-piece seals, fleet operators must buy two parts per wheel and inventory two parts per wheel. Installation is more complicated, time-consuming and costly. Scotseal covers more than 300 applications with half as many numbers.

Scotseal® *PlusXL*

The Scotseal® PlusXL design (fig. 5) with extended life capabilities is the premium performance seal from SKF offering maximum sealing life under virtually all driving conditions. The new high-temperature, synthetic lubricant-friendly material of the new Scotseal PlusXL, Hydrogenated Nitrile Butadiene Rubber (HNBR), is an excellent choice for frequent braking applications. HNBR elastomeric material provides heat resistance up to 300º F and broad compatibility with today's synthetic lubrication fluids. The unsurpassed exclusion properties allow the Scotseal PlusXL to perform in very harsh conditions. The new Scotseal PlusXL with the unique hand-installable design includes a fat footprint ensuring stability on the shaft. Worn hubs and spindles are not a problem for the Scotseal PlusXL.

Scotseal PlusXL (fig. 5).

Scotseal® *Longlife*

Building upon the success of the original Scotseal Classic design, SKF engineers had a great start in their development of a new extended life seal. Computer aided design (CAD) of lip geometry and the addition of an axial dirt excluder lip was combined with a newly formulated material to produce Scotseal® Longlife (fig. 6) – a premium performance seal with the characteristics required by many of today's demanding heavy duty environments.

Scotseal Longlife (fig. 6).

Scotseal Classic (fig. 7).

Scotseal® *Classic*

The original Self Contained Oil Type Seal, Scotseal® Classic (fig. 7), became the trucking industry standard – and the best value for more than 30 years. With literally trillions of road miles to its credit, Scotseal Classic has proven to be a solid choice for dependable, long lasting service. Time and time again, field studies show that when properly installed, using SKF tools and procedures, Scotseal Classic is a reliable performer for meeting the sealing requirements between brake maintenance intervals.

Scotseal family truck wheel seal operating conditions

	Scotseal Classic	Scotseal Longlife & Scotseal Plus XL
Surface speed	2000 F.P.M. MAX	5000 F.P.M. MAX
Temperature range	-40˚ to 250˚F (-40˚ to 121˚C)	-40˚ to 300˚F (-40˚ to 149˚C)
Pressure	2 p.s.i.	2 p.s.i.
Spindle finish	100 microinches MAX	100 microinches MAX
Spindle hardness	Rockwell C28	Rockwell C28
Spindle dia. tolerances	±0.003" Up to 4.000" ±0.004" 4.001 to 6.000" ±0.005" 6.001 to 10.000"	±0.003" Up to 4.000" ±0.004" 4.001 to 6.000" ±0.005" 6.001 to 10.000"
Bore runout	0.015" (TIR) MAX	0.015" (TIR) MAX
Spindle to bore misalignment	0.020" (TIR) MAX	0.020" (TIR) MAX
Seal O.D. tolerances	±0.004"	±0.004"
Bore tolerances	±0.015" From 3.001 to 7.000" ±0.002" 7.001 to 12.000"	±0.015" From 3.001 to 7.000" ±0.002" 7.001 to 12.000"

SKF TF Replacement Hubcaps

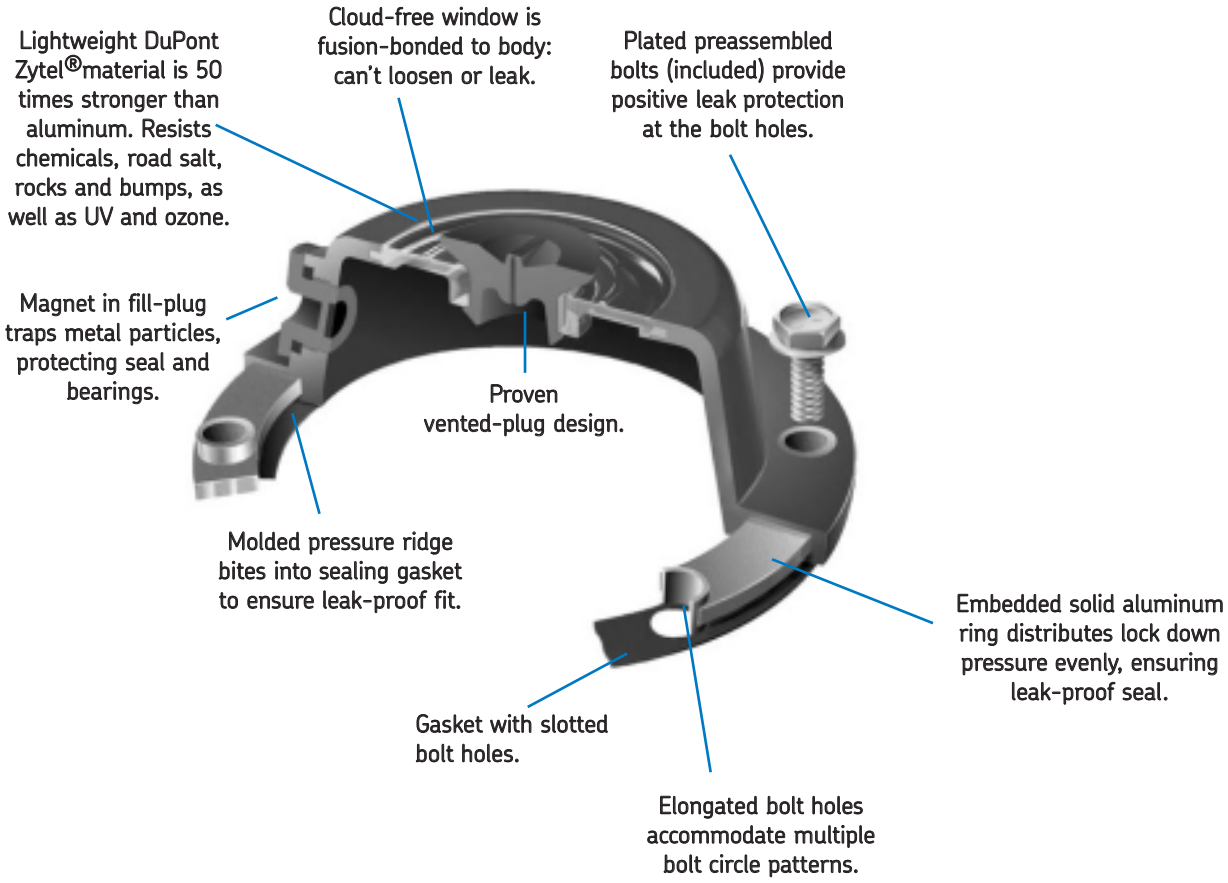
The Scotseal TF Hubcap is fifty times stronger than aluminum. Manufactured from DuPont Zytel®, Scotseal TF Hubcaps have been proven to withstand tough over-the-road conditions, resisting chemicals, road salt, rocks and bumps. The DuPont Zytel construction makes the TF Hubcap 1-1/2 pounds per axle lighter.

Additionally, the tamper-proof Scotseal TF Hubcap is specifically designed for use with today's synthetic grease packed systems. The vented TF Hubcap is easily identifiable in the fleet and protected against accidental contamination. This design forms a full 360 seal against the hubcap surface to protect wheel ends from damaging road spray, power washers and flooded docks.

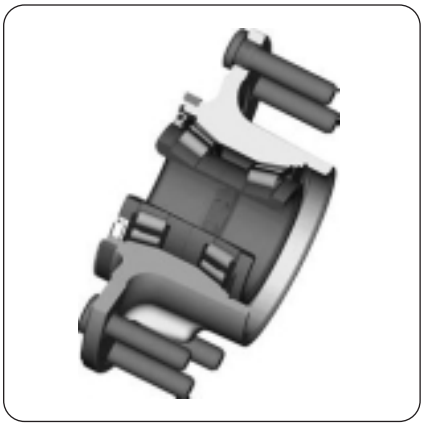
Oil Bath Type

Grease Packed Type (TP)

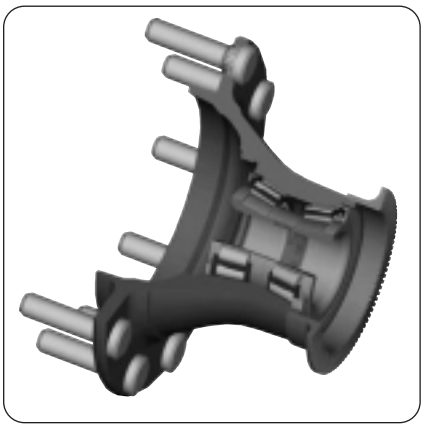
Oil Bath Type


Lightweight DuPont Zytel®material is 50 times stronger than aluminum. Resists chemicals, road salt, rocks and bumps, as well as UV and ozone.
Cloud-free window is fusion-bonded to body: can't loosen or leak.
Plated preassembled bolts (included) provide positive leak protection at the bolt holes.
Magnet in fill-plug traps metal particles, protecting seal and bearings.
Proven vented-plug design.
Molded pressure ridge bites into sealing gasket to ensure leak-proof fit.
Embedded solid aluminum ring distributes lock down pressure evenly, ensuring leak-proof seal.
Gasket with slotted bolt holes.
Elongated bolt holes accommodate multiple bolt circle patterns.

SKF LUNAR truck hubs



LUNAR trailer axle hub



LUNAR steer axle hub

Unlike conventional wheel ends, with separately installed, replaced and adjusted components, SKF LUNAR hubs, (for Longlife Unitized No Assembly Required), are fully integrated, factory-assembled units that are designed for extended trouble-free operation. Because they require virtually no maintenance for the life of the hub, these units have become a popular original equipment choice on new steer, drive and trailer axles.

As with all long life safety critical components, these units still require regular inspection. Refer to the truck or trailer manufacturer for specific inspection intervals and procedures.

Greater wheel-end stability

Under aggressive cornering, today's vehicles exert lateral separation forces on the bearings in excess of 6 tons. In a conventional hub, with its typical bearing clearance, these turning forces cause movement in the bearing arrangement.

In an SKF LUNAR hub, designed for a spindle that is straight, rather than tapered, an 8 ton clamping load is placed across the inner rings. This creates a rigid system that keeps the bearings and seal stable during excessive load conditions. The result? Higher safety, reduced maintenance.

CHAPTER 3 REVIEW

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any of the questions. This learning technique assures more than four times the normal retention rate for even this technical subject.

1. SKF designed the Scotseal specifically for _____ wheels.
   - ❑ a. trailer
   - ❑ b. bus
   - ❑ c. tractor front
   - ❑ d. all of the above

1. D

2. Scotseal's design is so efficient that it seals out _____.
   - ❑ a. water
   - ❑ b. salt
   - ❑ c. dust
   - ❑ d. all of the above

2. D

3. The Scotseal design utilizes a _____ .
   - ❑ a. heavy-duty dirt lip
   - ❑ b. secondary dirt lip
   - ❑ c. sealing lip
   - ❑ d. all of the above

3. D

4. With Scotseal Classic, _____ is reduced to zero.
   - ❑ a. the chance of axle damage from the seal
   - ❑ b. the effect of centrifugal force on the sealing element
   - ❑ c. both of the above
   - ❑ d. neither of the above

4. C

5. The Scotseal Classic's O.D. is coated with _____ which contains no abrasives or thinners.
   - ❑ a. Viton
   - ❑ b. Bore-Tite
   - ❑ c. engine oil
   - ❑ d. Lexan

5. B

6. With a Scotseal, everything including the sealing element turns.
❏ True ❏ False

6. F

7. The oil leaks suffered by the trucking industry of the late 1950's occurred because centrifugal force lifted the sealing lip from the axle.
❏ True ❏ False

7. T

8. Scotseal's sealing lip is both elastomeric and spring-loaded.
❏ True ❏ False

8. T

CHAPTER 4
SCOTSEAL REPLACEMENT

Faulty installation is one of the most common reasons a seal fails. No matter how well made a seal is, incorrect installation can make even a new seal worthless.

"Good practice" tips

Our experience has shown that there are many causes of wheel end leakage beyond the oil seal. If you look, you will find that leaking wheel ends leave clues pointing to which component or components are the culprits. Follow the guidelines of the checklist below as you service the wheel end. You may find that just changing the seal may not be your permanent solution.

Inspect for indications of leakage:

Under vehicle inspection

- Oil present past the seal
- Oil contaminated hub, brake hardware, brake shoes

External leakage

- Oil present around hubcap, in wheel cavity
- Oil present around axle flange (drive axle)

Disassembling the wheel end

(Caution: Block wheels, support vehicle on stands)

- Check condition of hubcap. Check flange, window and centerfill plug
- Check bolts and axle flange area on drive axle

Remove hubcap

(Axle flange on drive axle)

Check condition of lube

- Cloudy or milky indicates water
- Shiny indicates bearing wear
- Metal flakes present could indicate loose shavings from an axle component
- Grit and sand indicates lube contamination
- Smells burnt indicates overheating

Check condition of fastening system

- Verify end-play measurement before removing fastener
- Examine outer nut, washer (dowel, tang or 'D' type), inner nut, cotter pin

Remove outer bearing

- Inspect for signs of damage

Remove wheel or hub assembly, using a wheel dolly

- Check spindle
- Threads damaged
- Chamfer damaged

Set bearings aside for inspection

Remove seal

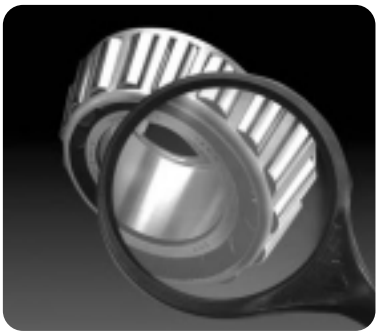
- Check hub
- Condition of chamfer
- Nicks, burrs, damage
- Consult the Failure Analysis section of the User's Manual

Helpful hints

- Stay organized – a messy shop is dangerous and inefficient.
- Keep loose components together
- It is important to not mix wheel-end components – bearings are "mates" that wear together. This includes new bearings.

- Do not use chisels, impact wrenches and torches
- Do not use hammers directly on seals or bearings

Do not use compressed air. After cleaning, dry with a clean paper towel or a clean rag. Air jets cause small abrasive particles to become jammed in between the bearing surfaces.



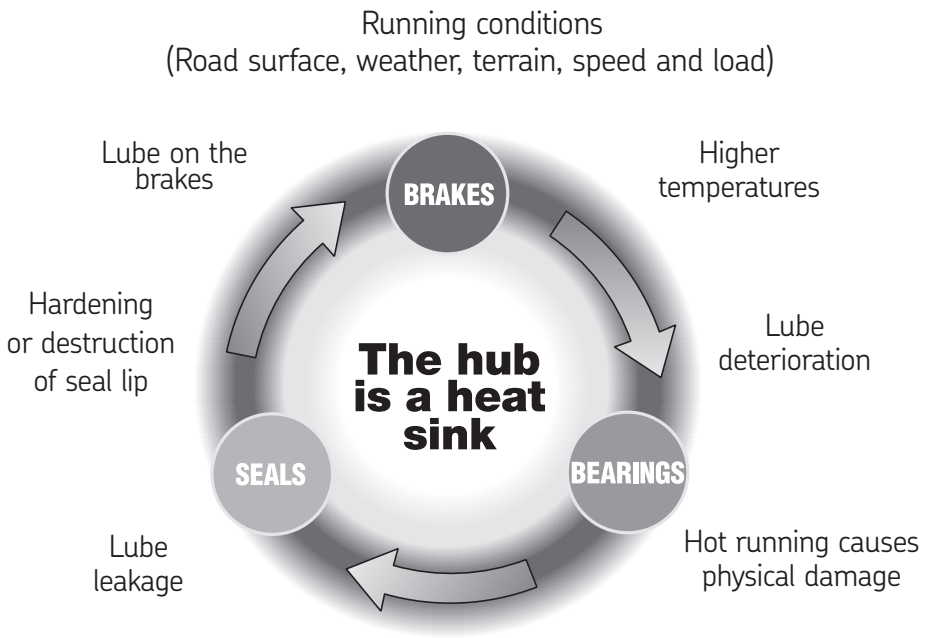
Bearings must be cleaned for inspection and re-use. Use only clean solvents – effectiveness of solvent in removing old lubricant depends on how clean the solvent is.

Good cleaning requires proper equipment such as:

- Solvent bath
- A filter system and regular changes of the solvent and the filters

The importance of proper lubricants

It is important to use the proper amount of lubricant when installing wheel end components. If the proper amount of lubricant is not used, the working combination of the bearings, seals and brakes can create a "heat sink," ultimately damaging the working condition of the entire wheel end.



Inspection of lubricant

Inspection of grease or oil can provide a clue to other problems. Remove a sample from the wheel end and check for the following:

- Presence of contaminants
- Burnt aroma
- Presence of water

Prior to re-installing bearings, always check for the proper lubricant.

Wheel end lubricants are formulated to match the requirements of the truck and bearing manufacturer.

- Always use specified lubricant
- Do not mix lubricants
- Chemical interaction between lubricants and seal materials can damage the seal
- Whenever possible, use a grease packer

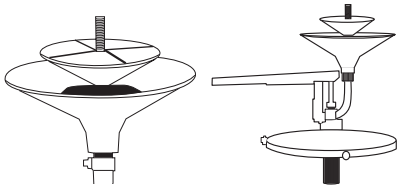
Grease and oil lubricants

The truck or trailer manufacturer has pre-determined that the wheel-end assembly is to be lubricated by grease or oil. The importance of following the manufacturer's specifications cannot be over emphasized – never change or mix grease and oil in the same assembly!

Always use lubricants as recommended by the manufacturer.

Grease lubricated wheel-ends

For proper lubrication, the grease must be packed into the cavities between the rollers and cage of the bearing cone. A mechanical grease packer is recommended in order to improve on the common procedure of filling the grease by hand. Also apply a light film of grease to the axle spindle for corrosion protection.



Typical mechanical grease packer

Two piece seal replacement vs. Scotseal replacement

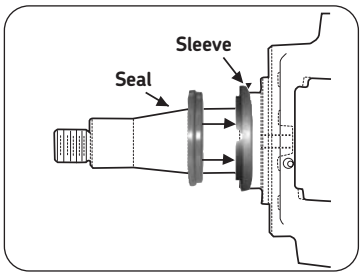


Figure 1

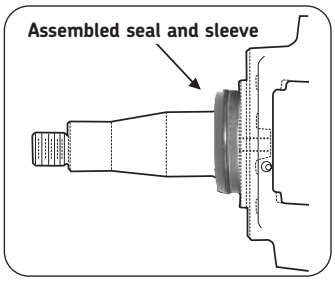


Figure 2

Some seal manufacturers utilize a two-piece design that includes a wear sleeve and an oil seal (fig. 1). Be aware that the original seal with the sleeve will have a larger ID dimension compared to the Scotseal® unitized design. Shown in fig. 2 is the two components assembled on the spindle. Assuring the correct seal requires specifications that match the spindle sealing surface diameter and the hub seal bore.

For example (fig. 3 and 3a), the seal component has an ID of 4.733" compared to the spindle diameter of 4.625". The sleeve component has an ID of 4.625" matching the spindle diameter. At times, in error, a comparison is made between the two-piece style seal component and a unitized Scotseal replacement. The ID dimensions will differ. Always check the spindle for any sleeve or axle ring and remove. Seals of this nature and Scotseals press into the hub bore, therefore outside diameters will match.

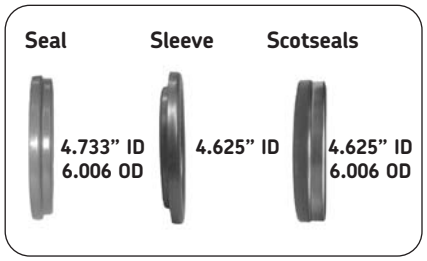


Figure 3

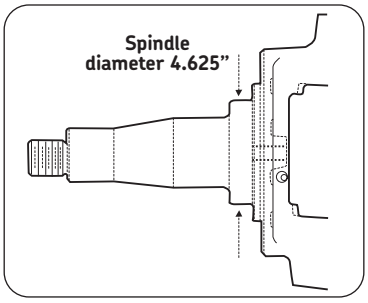


Figure 3a

Hub bore vs. seal bore

In some applications an oil seal will press fit into the bearing bore (fig. 4) instead of the seal or hub bore. Confusion arises when a replacement seal appears too large in the OD dimension when interpretation indicates that the replacement seal is a hub bore installation, but in fact it is a bearing bore installation. (fig. 5).

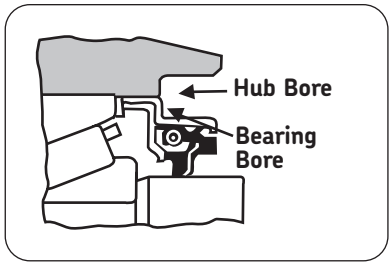


Figure 4

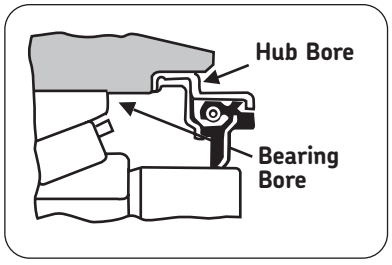
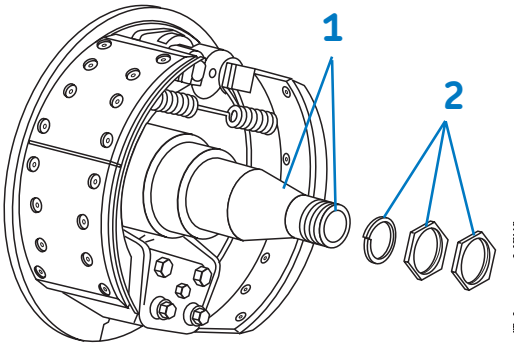


Figure 5

Inspection of the spindle and hub

1. Inspect the spindle and spindle threads for damage, and remove light frett. Also check for the following:
    - Spalling
    - Corrosion pits
    - Discoloration from overheating
    - Punch marks / chisel marks
    - Weld beads
    - Upset metal

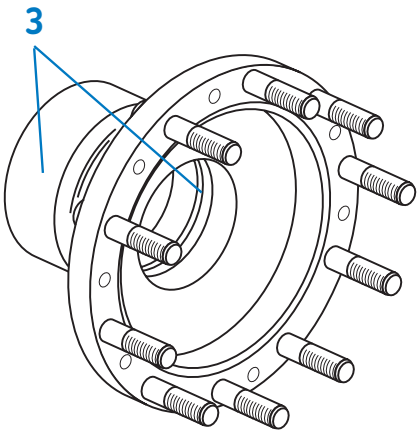
    Note: Damaged threads can be repaired using a pitch thread file or die nut.



2. Inspect the fastener / locknut / bearing adjustment nut / washer

    (The use of these spindle end components varies by truck or trailer manufacturer)

    Look for chisel marks or other deformation as a sign of improper installation, or an attempt to make temporary repairs.

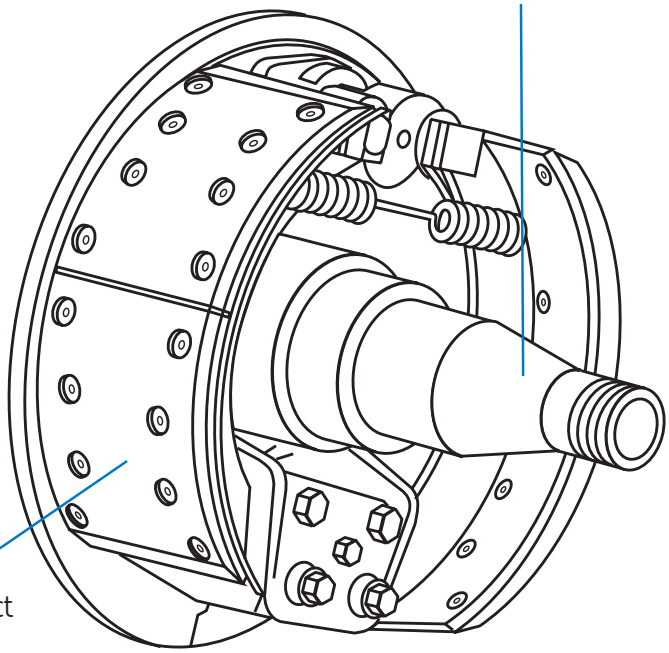


3. Inspect the inside and the outside of the hub. Look for the following:
    - Broken fasteners / bolts
    - Cracks in the housing
    - Damage to the hub and bore

    Note: If the bearing cup is loose in the hub, this indicates a serious condition and the hub must be replaced.

WARNING: Never work under a unit supported by only a jack. Always support the vehicle with stands. Block the wheels and make sure the unit will not roll before releasing brakes. Always wear eye protection.

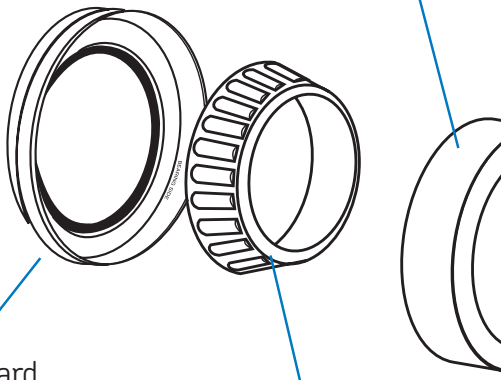
Wheel-end disassembly



Visually inspect spindle.

Visually inspect brakes.

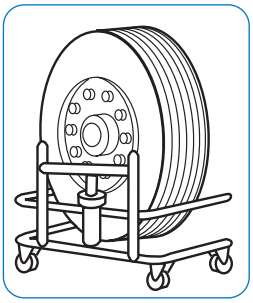
Inner bearing **cup** remains in hub unless it is damaged and needs replacement. **Always** replace bearings in sets (cup and cone).



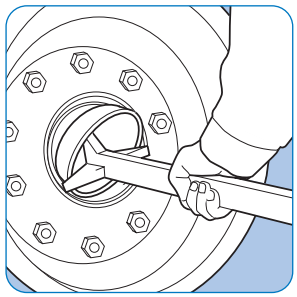
Remove seal and discard. **Never** re-use a seal. If seal shows damage **prior** to removal, keep it for failure analysis.

Remove bearing **cone** for cleaning and inspection.

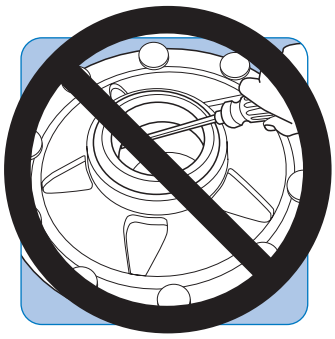
RECORD ANYTHING ABNORMAL ON WORK ORDER.



Always use a wheel dolly to remove the wheel assembly. Drain oil if hub is oil lubricated. When the wheel is removed, make a visual inspection for signs of damage, leaks, or wear on undercarriage components.



Removal of the **seal** with an SKF SRT-1 is recommended to avoid damaging the bearing or the hub bore.

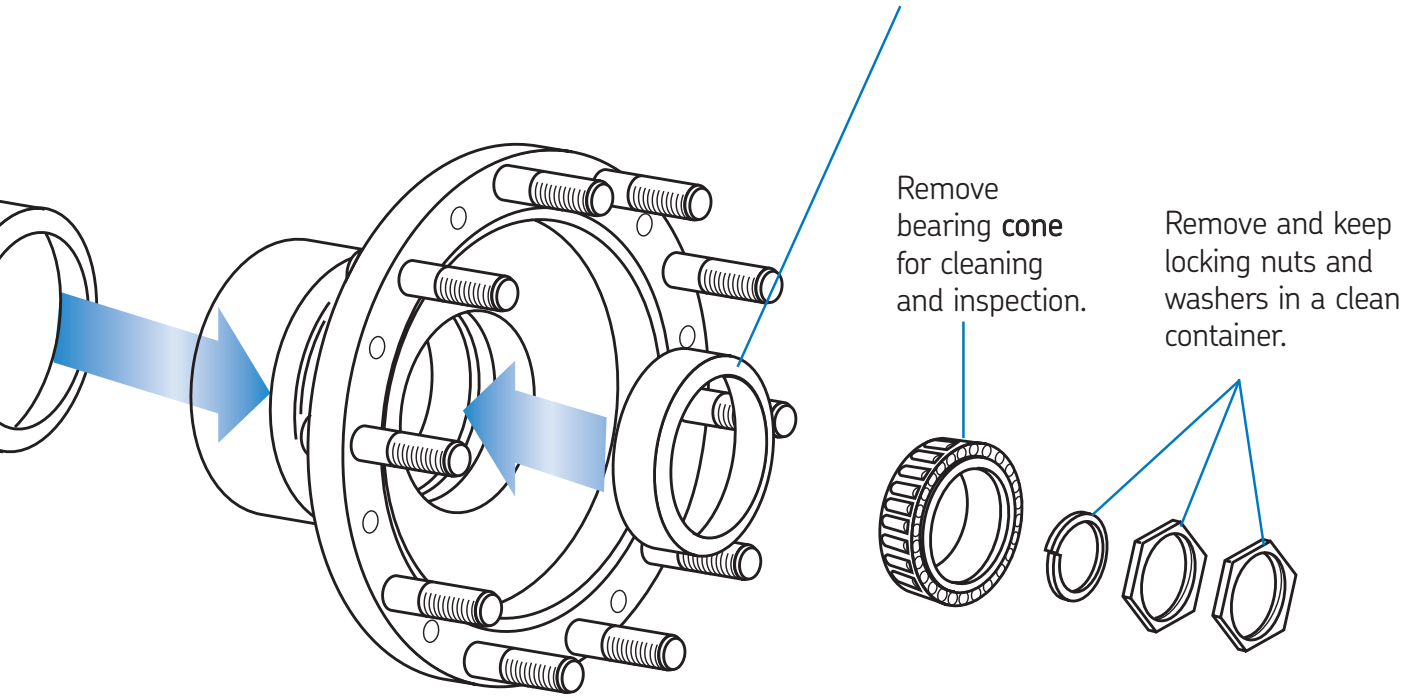


Hammers, chisels and improper prying tools cause damage to bearings and hubs and can lead to catastrophic results. **USE ONLY SPECIFIED TOOLS.**

Wheel-end component inspection

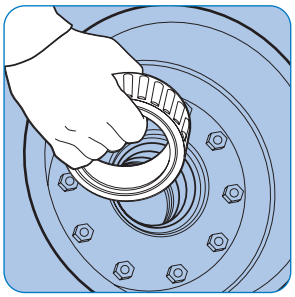
Because most of the components can only be inspected when they are removed from the assembly, it is also important to use the proper removal tools to avoid damage, or to alter signs of existing damage.

Outer bearing **cup** remains in hub unless it is damaged and needs replacement. **Always** replace bearings in sets (cup and cone).

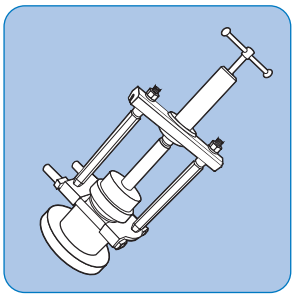


Remove bearing **cone** for cleaning and inspection.

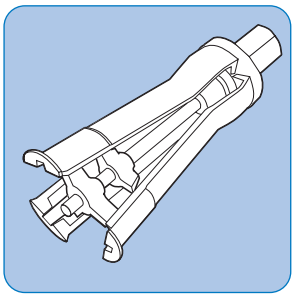
Remove and keep locking nuts and washers in a clean container.



The **bearing cone** can usually be removed from the hub by hand. When removed, place the bearing in the clean containers with the other components.



If **bearing cone** is seated too firmly for hand removal, use a special removal tool of the type shown above.



Bearing cups are too tightly fitted in the hub bore to be removed by hand. If removal is required, use a special tool of the type shown above.

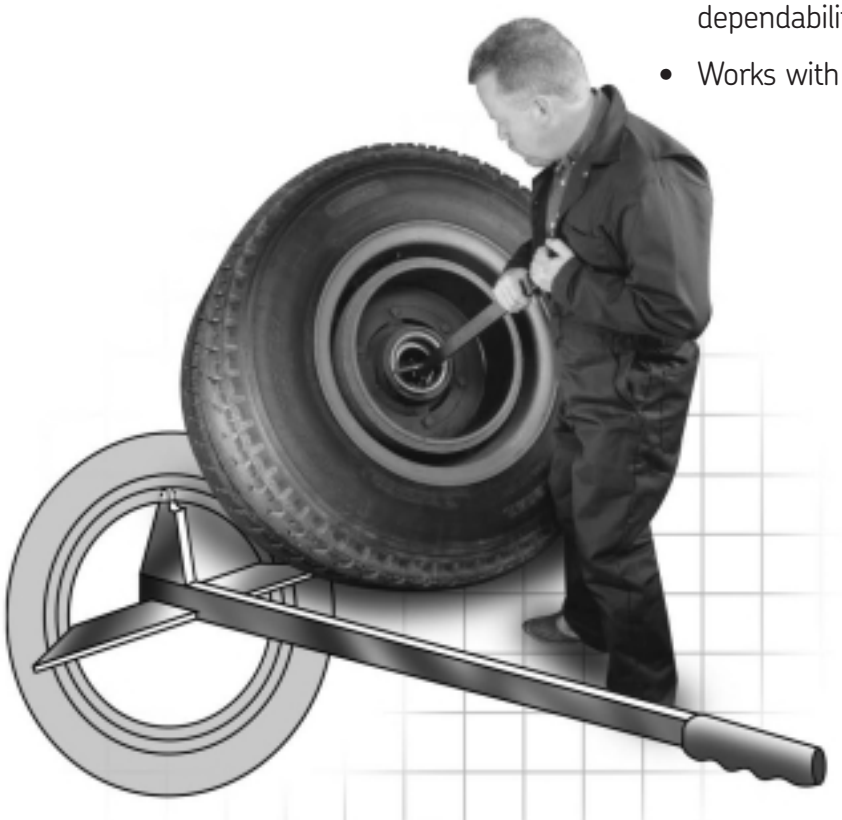
The SRT-1 Seal Removal Tool

U.S. Patent No. 5,617,621

The SKF SRT-1 Seal Removal Tool is recommended for removal of most tractor, truck, dolly or trailer wheel seals. With the wheel hub assembly removed from the axle, simply insert the hook tip of the tool between the seal and bearing. The unique design of the tool allows you to use leverage to easily and safely remove the seal, without damaging the spindle.

Simple design, rugged construction and ergonomic features increase your productivity and eliminate costly bearing damage.

- Saves time – no more laborious prying against bearings or driving out seals.
- Saves bearings – tool grabs seal only and bearings go undamaged.
- Easy to use – wedges and long handle provide exceptional leverage.
- Rubber grip for security in handling.
- Heavy duty construction for long life and dependability.
- Works with steer, drive, and trailer wheel seals.

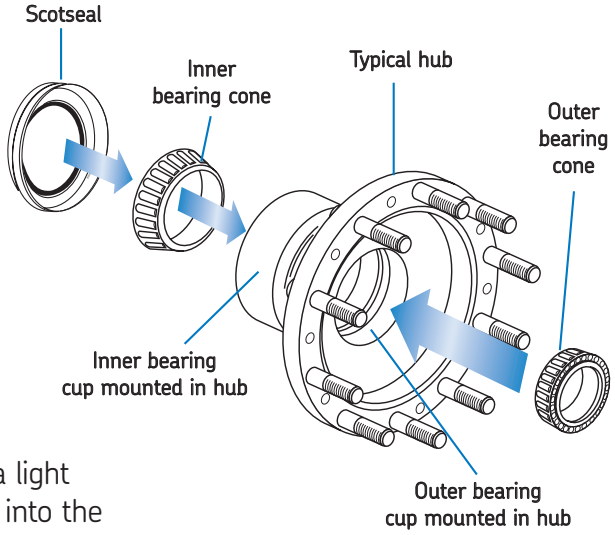


WARNING:
Do not add a handle extension to the tool. This tool is to be used for seal removal only.

Bearing and seal installation

General instructions

Wheel hub designs differ from one manufacturer to another. However, the correct procedures for installing bearings and seals remain basically the same. Care in handling components and proper tooling are always the critical factors in all procedures which lead to Trouble-Free Operation.



Components in a typical hub assembly

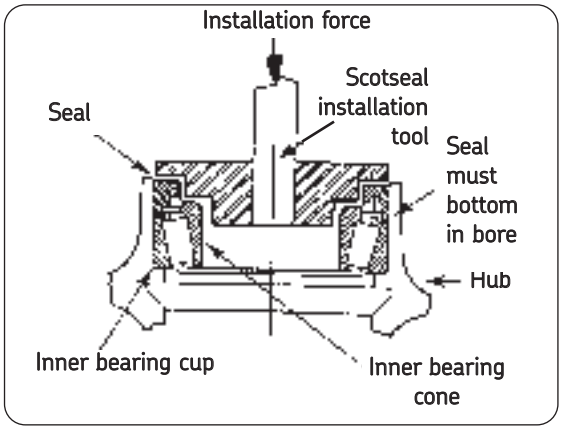
Oil lubricated wheel-ends

Coat the bearing cones with a light oil film before inserting them into the bearing cups. Always use the specified oil for replacement and do not mix lubricants.

Installing bearing cup and seal

Avoid any direct hammering on the bearing or the Scotseal – this will cause deformation or damage, which will result in premature failure. Use a simple vertical press to push the bearing cup into correct position in the hub.

Use a recommended Scotseal installation tool to install the Scotseal Classic or Longlife correctly in the hub. When hammering on the tool, be sure to stop when the seal is "bottomed"; you will hear a definite tone change. Do not add extra blows or it will cause immediate damage to the seal. Scotseal PlusXL requires no special installation tool.



Note: if the tire is mounted on the hub, place the entire assembly against a solid surface at a 45° angle before final setting.

Installation procedures: Scotseal® PlusXL

This seal is hand installable. No special tools are required.

Lightly lubricate the OD and ID with the fluid being retained.

A rubber mallet may be used to tap into place.

Press the seal into the bore evenly by hand.

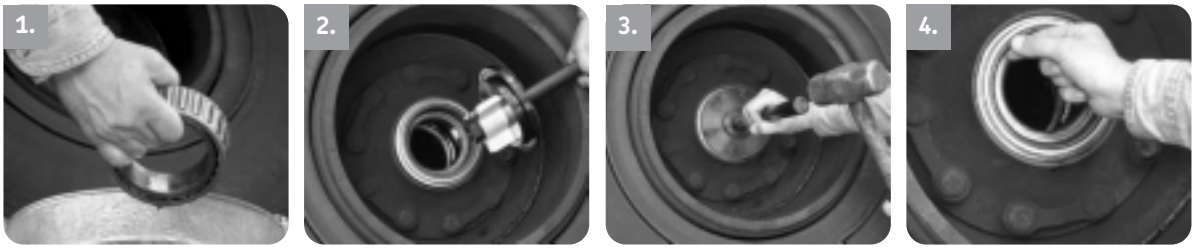
Caution: Do not install the Scotseal® *PlusXL* directly onto the spindle.

Place the hub (wheel) assembly flat or at least a 45° angle for seal installation.

1. Pre-lube the inner bearing cone with the lubricant that is being retained and place it into the hub.
2. Lightly lubricate the seal O.D. and I.D. evenly with the fluid that is being retained. Also apply a thin layer of oil on the hub bore that the seal is being pressed into. NEVER INSTALL DRY.
3. Press the seal by hand evenly into the bore. A rubber mallet or other soft-faced tool may be used to gently tap the seal into place. Be sure that the seal is evenly seated and bottomed in the bore. As in any seal installation, apply an even driving force to avoid cocking the seal or damaging the flange surface.
4. Allow seal to set for about 5 minutes prior to installing hub assembly onto spindle.

Caution: Install a new seal if the seal is cocked or damaged during or after installation.

Installation procedures: Scotseal® Classic / Scotseal® Longlife



Caution: Do not install the Scotseal® directly onto the spindle.

Place the hub (wheel) assembly against a solid surface or bench at a 45° angle for seal installation. This aids in centering the bearing and seal in the hub bore. Clean bore of any particles, rust or grease.

1. Pre-lube the inner bearing cone with the lubricant that is being retained and place it into the hub.
2. Place the Scotseal® Classic or Scotseal® Longlife into the hub bore and insert the tool assembly with centering plug into the seal. Note: Be sure to wear proper eye protection.
3. Hold the tool handle firmly and straight, and drive the seal with firm hammer strokes until the seal is squarely seated. Continue driving the seal into the hub until the sound of impact changes.
4. After the seal is bottomed in the bore, check for freedom of movement by manually moving the packing of the seal up and down. Ensure that the inner bearing rotates freely.

Caution: Install a new seal if the seal is cocked or damaged during or after installation.

The Scotseal® Toolboard

- Keeps tools orderly and lessens chances of tools being misplaced or damaged
- Sturdy metal construction – mounts easily on shop wall
- Fitting chart included
- Just order Part No. TB-1

Installation tooling:

Scotseal® Classic / Scotseal® Longlife

Tool selection

SKF Scotseal® Classic and Scotseal® Longlife are to be installed using only SKF Scotseal® installation tools. (See Chart A below)

Centering the seal

Precisely matched centering plugs are engineered to fit within the inside diameter of the inner bearing cone and allow accurate centering of the Scotseal in the bore of the hub, as well as preventing cocking of the seal. Chart B below provides correct matchup of bearing cone and centering plug.

Chart B
MATCHUP OF BEARING CONES & CENTERING PLUGS

BEARING CONE NO.	CENTERING PLUG NO.	BEARING CONE NO.	CENTERING PLUG NO.	BEARING CONE NO.	CENTERING PLUG NO.
495AX	708	749	719	39585	704
497	711	749A	710	42688	708
539	701	749S	719	45284	700
555S	702	756A	709	45285	700
557A	703	758	711	47678	708
559	704	759	712	47685	710
560	706	760	717	47686	710
567	707	776	715	47687	710
568	731	780	718	52400	718
575	708	3778	730	52401	718
580	710	3982	704	JH217249	719
582	710	3984	706	JM205149 A	722
593	712	4595	701	JM207049 A	723
594	715	5557	721	JM511946	724
594A	715	5760	708	JM716649	719
595	710	6379	705	JM718149	713
596	711	6386	706	JM719149	733
598	714	6386A	706	HM212044	703
598A	714	6389	706	HM212046	704
639	704	6461	708	HM212047	704
641	706	6461A	708	HM212049 X	706
659	708	6559	710	HM212049	706
663	710	6580	712	HM215249	707
663A	710	28995	703	HM218248	713
664	732	33281	716	HM516449	710
665	711	33287	707	HM518445	712
665A	711	33895	701	H715345	716
68IA	714	39578	701		
683	715	39580	702		
687	718	39581	702		

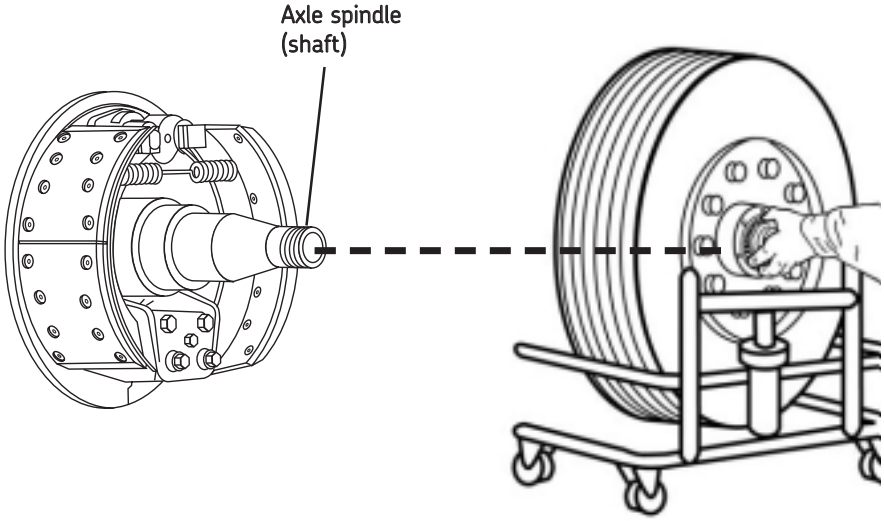
Chart A
DRIVE PLATES & SEAL MATCHUPS
(Drive plates in bold numbers with matching seal numbers)

427	**441**	**451**	**463**
34387	40086	46305	27438
36274	40090	46306	28758
36285	**445**	46308	28820
36358	39380	**452**	28832
36365	39420	42623	**465**
428	39425	42624	43752
31175	42550	42630	43764
31244	42672	42631	43765
31264	42800	**453**	43800
31266	**446**	50190	**472**
31281	43860	52660	39380
31307	43865	52664	(w/disc
32470	43875	**457**	brks.)
435	46390	40040	**474**
47690	47483	40136	52658
47693	48297	40139	**484**
47696	48298	40146	44922
47697	48690	40147	44964
47698	48792	**461**	45010
48000	48794	45152	45099
436	48796	45160	45100
34975	48884	45162	45103
35000	50124	45163	45108
35001	**448**	**462**	450737
35060	38709	38747	42625
35066	39988	38750	
35072	39990	38780	
35075	**449**	38782	
35102	47686	38783	
35103			

Installing hub assembly

DO NOT ATTEMPT TO INSTALL THE HUB ASSEMBLY BY HAND!

Whether the hub is with or without the tire, do not install it without mechanical support.



1. **When installing the hub assembly** over the axle spindle, be sure to align the hub bore to the center of the spindle. Mechanical supports will allow you to do this without scraping or otherwise damaging the spindle, the threads, and in particular the seal.
2. **Install the outer bearing cone and adjusting nut.** Tighten nut only until it is snug against the bearing cone. DO NOT USE A PNEUMATIC TOOL during this part of the procedure. Be sure to maintain support of the hub assembly until the adjusting nut is secure. Failure to do so may cause damage to the seal and subsequent leakage of lubricant.
3. **Remove the hub support** so that the hub is resting on the bearings. Check for free rotation of the bearings. Never allow hub to rest on seal.
4. **Follow wheel bearing adjustment** as instructed on following page.

Wheel bearing and end play adjustment procedures

WHEEL BEARING ADJUSTMENT PROCEDURE

STEP 1: Lubricate the wheel bearing with clean axle lubricant of the same type used in the axle sump or hub assembly.
Note: Never use an impact wrench when tightening or loosening lug nuts or bolts during the procedure.

INITIAL ADJUSTING NUT TORQUE	INITIAL BACK OFF	FINAL ADJUSTING NUT TORQUE	BACK OFF			JAM NUT TORQUE		ACCEPTABLE END PLAY
			AXLE TYPE	THREADS PER INCH	FINAL BACK OFF	NUT SIZE	TORQUE SPECIFICATIONS	
STEP 2	STEP 3	STEP 4		STEP 5	STEP 6	STEP 7		STEP 8
200 lb•ft (271 N•m) WHILE ROTATING WHEELS	ONE FULL TURN	50 lb•ft (68 N•m) WHILE ROTATING WHEELS	STEER (FRONT) NON-DRIVE	12	1/6 TURN *	INSTALL COTTER PIN TO LOCK AXLE NUT IN POSITION		.001"-.005" (.025mm-.127mm)
				18	1/4 TURN *			
				14	1/2 TURN	LESS THAN 2 5/8" (66.7mm)	200-300 lb•ft (271-407 N•m)	
				18				
			DRIVE	12	1/4 TURN	DOWEL TYPE WASHER	300-400 lb•ft (407-542 N•m)	AS MEASURED PER PROCEDURE WITH DIAL INDICATOR
				16		TANG TYPE WASHER**	200-275 lb•ft (271-373 N•m)	
			TRAILER	12	1/4 TURN	2 5/8" (66.7mm) and over	300-400 lb•ft (407-542 N•m)	
				16				

* If dowel pin and washer (or washer tang and nut flat) are not aligned, remove the washer, turn it over, and reinstall. If required, loosen the inner (adjusting) nut just enough for alignment.

** Bendable type washer lock only: Secure nuts by bending one wheel nut washer tang over the inner and outer nut. Bend the tangs over the closest flat perpendicular to the hang.

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Wheel bearing end play verification

Wheel bearing end play is the free movement of the wheel assembly along the spindle axis. It is recommended, for verification purposes, that wheel bearing end play be measured with a dial indicator. (Example in photo below.)

Step 1 Make sure the brake drum to hub fasteners are tightened to the manufacturers' specifications.

Step 2 Attach a dial indicator with its magnetic base at the bottom of the hub or brake drum.

Step 3 Adjust the dial indicator so that its plunger or pointer is against the end of the spindle with its line of action approximately parallel to the axis of the spindle.

Note: For aluminum hubs, attach the magnetic base of the indicator to the end of the spindle with the plunger against the hub or brake drum.

Step 4 Set the dial indicator to zero by rotating the gauge face so the zero mark lines up with the gauge needle. For digital indicators, push the zero-out button.

Step 5 Grasp the wheel assembly at the 3 o'clock and 9 o'clock positions, while oscillating it to seat the bearings. Read bearing end play as the total indicator movement.

Note: If end play is not within specifications, refer to the readjustment procedure of SKF technical bulletin No. TBF 9301.

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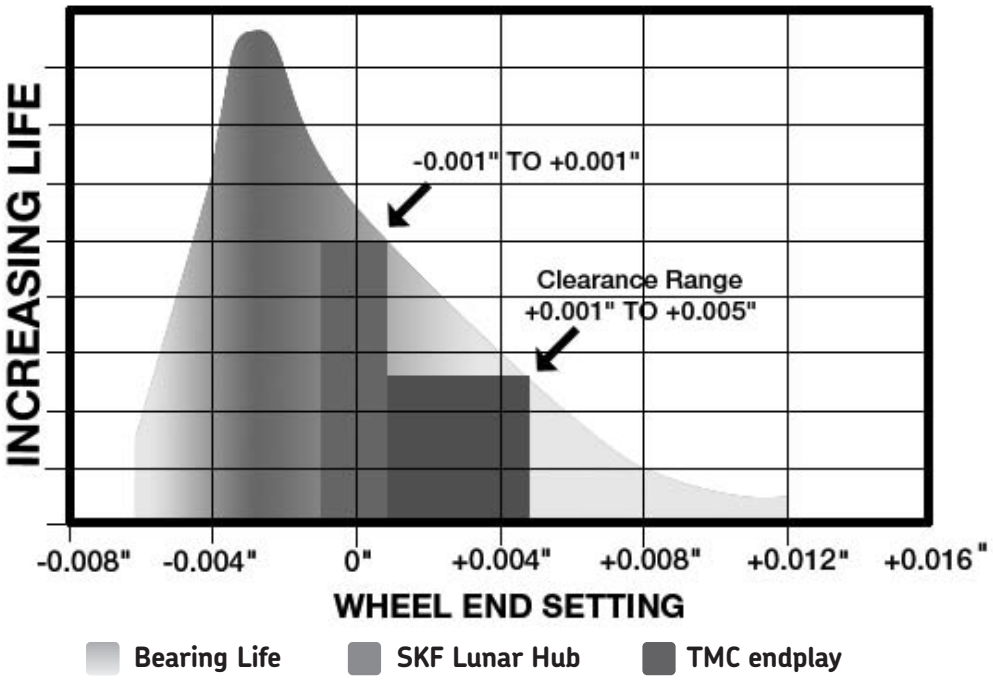
The clearance problem – solved.

The biggest obstacle to effective wheel-end maintenance is setting the correct bearing clearance. In fact, most wheel-end bearing failures are the result of incorrect clearance adjustment. While in general practice, the wheel is rotated only 3 times during adjustment, it can take as many as 18 revolutions for bearings to become fully seated.

How important is clearance to bearing life? Immense. As this graph illustrates, too much or too little pre-load – even a few thousandths of an inch – can dramatically effect fatigue life.

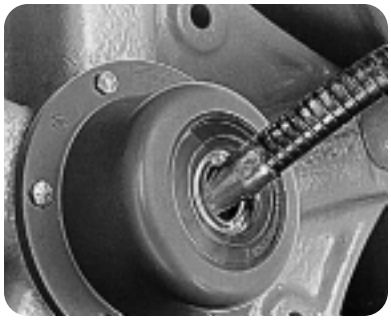


An experienced technician working with the right tools typically achieves settings ranging from 1 to 5 thousandths of an inch, but that doesn't take into account what happens to clearance when the bearings become fully seated. So even if a technician sets the bearings as accurately as possible in the shop, bearing clearance can be highly inaccurate a mere forty yards down the road.

The SKF LUNAR Hub solves adjustment problems by precisely match-grinding all the components to achieve a +/- 0.001" clearance control. Correct clearance adjustments produce increased bearing and seal life, ultimately increasing the wheel-end's lifetime and a fleet's profitability.

Bearing adjustments below zero enter preload stage and cannot be measured in the shop. Over tightened bearings, as you can see, lead to bearing failure. On the other hand, too loose bearing adjustment will also lead to bearing failure. Re-adjust bearings if an end play cannot be read or if end play is greater than .005" to ensure optimal bearing life.

Hubcap installation procedure



Procedure

1. Hub mating surface must be free of dirt, burrs and radial score lines.
2. Hub mating surface, hubcap flange and gasket should not be greased or oiled.
3. Always install and re-install a hubcap with a new gasket.
4. When using a Tamper Proof system with synthetic grease, never fill hubcap with oil.

Bolt on hubcaps

- Lockwashers of the split, conical or internal toothed design may be used in conjunction with the fastening bolts. Do not use flat washers.
- Thread all bolts loosely, then tighten down bolts uniformly in a star pattern per the following recommended torque values:

TF (Zytel) Hubcap with embedded metal ring	12-16 lbs./ft.
Stamped Steel Hubcaps	10-14 lbs./ft.
Plastic Hubcap with external metal ring	6-10 lbs./ft.

Threaded hubcaps

- Lightly lubricate the threads of the hubcap and the O-ring, with the lubricant that is being retained.
- Install the O-ring onto the hubcap.
- Install the hubcap assembly onto the hub.
- Using an 8-point 4 13/16" opening x 4 1/4" high socket, torque to the following recommended values:

Lexan	60-70 lbs./ft.

Oil fill

Through center fill port

- Fill wheel end assembly through centerfill port with the specified grade of oil. Wheel hub configurations vary, allowing different amounts of oil to be added depending on design. Allow for the oil to seep through the outer bearing and fill the hub cavity. Continue to add oil until the oil reaches the oil level fill line as indicated on the hubcap.
- Install center fill hubcap plug.

Through side fill port

- Fill wheel end assembly through side fill port with the specified grade of oil. Wheel hub configurations vary, allowing different amounts of oil to be added depending on design. Allow for the oil to seep through the outer bearing and fill the hub cavity. During this fill operation, **DO NOT ALLOW THE OIL TO GO ABOVE THE CENTERLINE OR WEEP HOLE.** This may result in a weeping condition that may be perceived as a leaking hubcap. Continue to add oil until the oil reaches the oil level line as indicated on the hubcap.
- Install side fill hubcap plug per the following recommended torque values:

3/8" - 18 NPT

Pipe Plug **100-140 lbs./in.**

3/4" - 16 UNF (Zytel)

Side Fill Plug **15-25 lbs./in.**

Clean up any overspills that would give the appearance of a leaky hubcap.

Grease fill: See TMC RP631

"Recommendations for Wheel End Lubrication" and the vehicle manufacturer's recommendation for proper fill procedure.

CHAPTER 4 REVIEW

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any of the questions. This learning technique assures more than four times the normal retention rate for even this technical subject.

1. The SKF SRT-1 Seal removal tool is recommended for removal of seals in_____.
   - ❑ a. Tractors
   - ❑ b. Trucks
   - ❑ c. Trailers
   - ❑ d. All of the above

1. D

2. The SKF SRT-1 saves bearings by grabbing the_____.
   - ❑ a. Bearings
   - ❑ b. Seals
   - ❑ c. Bearings and seals
   - ❑ d. None of the above

2. B

3. The Scotseal® PlusXL should not be installed directly on the _____.
   - ❑ a. bearing
   - ❑ b. hub
   - ❑ c. spindle
   - ❑ d. none of the above

3. C

4. Over tightened bearings, can lead to _____.
   - ❑ a. Bearing failure
   - ❑ b. Increased bearing life
   - ❑ c. Increased seal life
   - ❑ d. Non of the above

4. A

5. Correct procedures for installing bearings and seals remains basically the same for all hub manufacturers.
   ❑ True ❑ False

5. T

6. Direct hammering on a bearing or Scotseal will cause premature wheel end failure.
   ❑ True ❑ False

6. T

7. Changing the seal is always a permanent solution for wheel end leakage.
   ❑ True ❑ False

7. F

8. The biggest obstacle to effective wheel-end maintenance is setting the correct bearing clearance.
   ❑ True ❑ False

8. T

9. Always install and re-install a hubcap with a new gasket.
   ❑ True ❑ False

9. T

10. Faulty installation is one of the most common reasons a seal fails.
    ❑ True ❑ False

10. T

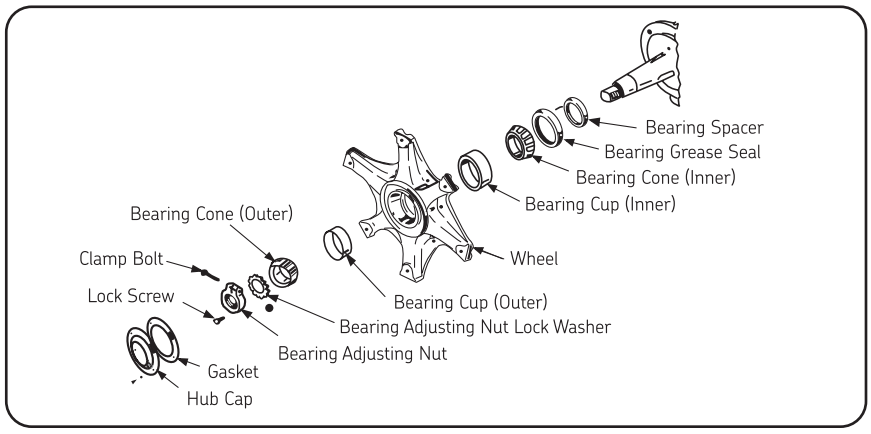
CHAPTER 5
WHEEL END GREASE SEALS

In this chapter, you will find instructions for installing grease seals on axles. Scotseals are needed for oil bath wheel ends.

First, you must replace the seal whenever you pull the wheel.

The old seal will most likely be nicked or bent when the wheel was removed. Some of the seal's press fit in the hub will have been lost during removal of the bearing. The seal will not fit as tight as it should which will prevent it from retaining lube and excluding dirt. Reusing an old seal can cause costly problems such as failure of the wheel bearing or brake lining.

Before discarding the old seal, check it for damage. This will be explained in Chapter 8. Then proceed with the following guidelines for seal installation.



A typical front wheel assembly is shown above (fig. 1).

Seal installation (fig. 1)

Remove the wheel assembly

1. Jack up the wheel off the ground and support the axle with safety stands.

2a. Remove the hubcap, axle nut locking device (cotter pin, safety wire, locking washer tab or bolt).

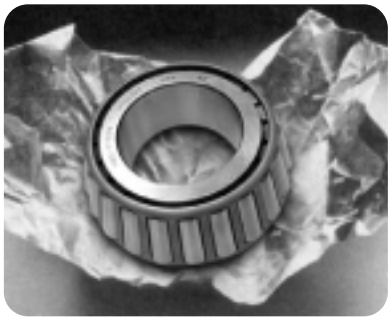
2b. Remove the axle flange nuts and lock washers. Install pulling screws in axle flange holes, if provided. If not, strike the axle flange in the center sharply with a heavy hammer. It may require several blows to bounce the shaft loose so the tapered washers and axle shaft can be removed.

3. Remove the locking nut, adjusting nut, lock washer and outer bearing cone. Since the arrangement and design of washers, locks and nuts is different with each manufacturer, be sure to note the order in which they should be replaced after the seal is installed.
4. Slide the wheel and hub assembly off the spindle. Be careful not to drag the inner bearing over the spindle thread. If possible chain the wheel to the dolly for safety.
5. Remove the bearing spacer and pin from the spindle. Pry out the old seal with a rolling head pry bar. Using a drift to drive the bearing and seal out can damage the bearing cage.
6. Remove the inner bearing cone. Record the worn seal's part number so you can refer to it when selecting the new seal replacement.
7. If pulling more than one wheel, be sure to keep all of the parts of each wheel assembly together and separate from the other wheels.

Cleaning and inspection

1. Clean the hub cavity and cap, removing all old lubricant. Use a brush to clean the drum and brake mechanism. Wipe the spindle clean.
2. Use a recommended solvent to remove dirt and grease from the bearing and related wheel/axle parts. Rinse the bearing in another – separate – bucket of clean solvent (fig. 2). Let the bearings dry naturally in the air.
3. Inspect bearing cones and cups. Replace them if they are pitted, rough or damaged.
4. Dip clean bearings in a protective lubricant, or coat bearing surfaces with a light grease. Wrap the bearings in waterproof paper and place them in a clean box or carton. Keep bearings covered until you are ready to install the new seal (fig. 3).
5. Inspect the spindle bearing and seal surface for burrs or roughness. Be careful not to scratch the sealing surfaces when polishing out roughness. Even small marks can permit lubricant to seep out under the sealing lip.
6. Check where the seal lip makes contact. If you can feel a worn groove with your fingernail, there will be leakage, even with a new seal (see Speedi-Sleeves, Chapter 7). Replace the bearing spacer if it is grooved or worn.

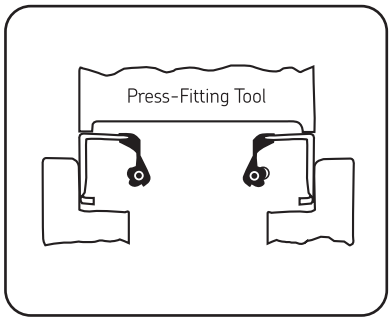
Rinse the bearing in clean solvent (fig. 2).



Store bearings in protective, waterproof paper (fig. 3).

Installation checklist

1. **Check the bore.** The leading edge must be deburred. A rounded corner or chamfer should be provided.
2. **Check the shaft.** Remove surface nicks, burrs, grooves and spiral machine marks (machine lead).
3. **Check the shaft end.** Remove burrs or sharp edges. The shaft end should be chamfered in applications where the shaft enters the seal against the sealing lip.
4. **Check splines and keyways.** Sharp edges should be covered with a lubricated assembly sleeve, shim stock or tape to protect the seal lip.
5. **Check dimensions.** Be sure shaft and bore diameters match those specified for the seal selected.
6. **Check for parts interference.** Watch out for other machine parts that might rub against the seal and cause friction and damaging heat.
7. **Check the seal.** Damage may have occurred prior to installation. A sealing lip that is turned back, cut or otherwise damaged should be replaced.
8. **Check seal direction.** Make sure that the new seal faces in the same direction as the original one. Generally, the lip faces the lubricant or fluid to be retained.
9. **Use the correct installation tool.** Press-fitting tools should have an outside diameter approximately .010" smaller than the bore size. For best results, the center of the tool should be open so that pressure is applied only at the outer edge of the seal (fig. 4).
10. **Pre-lubricate the sealing element.** Before installation, wipe the element with the lubricant being retained.
11. **Never hammer directly on the surface of the seal.** Use proper driving force, such as a soft-face tool, arbor press, or soft workpiece (wood). Apply force evenly around the outer edge to avoid cocking the seal.
12. **Position the seal properly in the housing and inspect for alignment and installation damage.**



The press-fitting tool should be .010" less than the bore I.D. (fig. 4).

Post-installation tips

- When painting, be sure to mask the seal. Avoid getting paint on the lip, or the shaft where the lip rides. Also, mask the vents so they will not become clogged.
- If paint is to be baked or the mechanism otherwise subjected to heat, the seals should not be heated to temperatures higher than their materials can tolerate.
- In cleaning or testing, do not subject seals to any fluids or pressures that could damage them. Check the Compound Selection Chart in the SKF Handbook of Seals (Catalog #457010) when in doubt.

Reassemble the wheel

1. Pack the hub cavity between the two bearing cups with an approved wheel bearing grease to the level of the cup's smallest diameter. When using a semi-fluid grease, follow TMC RP631 and vehicle manufacturer's recommendation for proper fill procedure.
2. Pack the bearing cones, using a pressure packer if possible. If not, force the grease into the cavities between the rollers and cage by hand from the large end of the cone. Coat the ends of the rollers freely with grease.
3. Insert the inner bearing cone in the grease-filled hub. Place the pre-lubed seal in the hub with the lip facing the bearing cone. Seat it properly.
4. Position the spacer on the spindle if present. Align the hole and pin. Apply a light film of lubricant to the spindle to prevent rusting.
5. Use a wheel dolly to center the wheel assembly on the spindle. Push the wheel on far enough so the seal is in safe contact with its riding surface on the bearing spacer or spindle. Install the outer bearing cone, washer and adjusting nut in reverse order of removal.
6. Adjust the bearing according to the TMC RP found in Chapter 4. Secure the locking nut and locking device. Position the new gasket on the hub cap, and install.
7. For oil bath seal replacement, see Scotseal Replacement Chapter 4.

CHAPTER 5 REVIEW

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any of the questions. This learning technique assures more than four times the normal retention rate for even this technical subject.

1. An old seal should be replaced whenever _____.
   - ❏ a. it has been nicked
   - ❏ b. some of the press-fit in the hub is lost
   - ❏ c. it has been bent
   - ❏ d. the wheel is pulled from the vehicle

1. D

2. Reusing an old seal can cause failure of the _____.
   - ❏ a. wheel
   - ❏ b. brake lining
   - ❏ c. bearing
   - ❏ d. any of the above

2. D

3. _____ can damage the bearing cage.
   - ❏ a. Prying out the old seal with a rolling head pry bar
   - ❏ b. Driving the bearing and seal out with a drift
   - ❏ c. Removing the inner bearing cone
   - ❏ d. All of the above

3. B

4. Bearing cones and cups should be _____ if they are pitted or damaged.
   - ❏ a. lubricated
   - ❏ b. replaced
   - ❏ c. rotated
   - ❏ d. all of the above

4. B

5. A light film of _____ prevents rusting on the spindle.
   - ❏ a. SKF Bore-Tite
   - ❏ b. lubricant
   - ❏ c. wax paper
   - ❏ d. powdered metal epoxy type filler

5. B

6. The press-fitting tool used in installation should be _____ the bore I.D.
   - ❏ a. .010" less than
   - ❏ b. .010" more than
   - ❏ c. .025" less than
   - ❏ d. equal to

6. A

7. Edges of the keyway and spline should be covered with _____.
   - ❑ a. straight mineral oil
   - ❑ b. lubricated assembly sleeve
   - ❑ c. ordinary engine oil
   - ❑ d. SKF Bore-Tite

7. B

8. When you pull the wheel, change the seal.
   - ❑ True ❑ False

8. T

9. It is unnecessary to check the old seal for damage before dumping it.
   - ❑ True ❑ False

9. F

10. Small scratches on the shaft can allow some lubricant to seep under the sealing lip.
   - ❑ True ❑ False

10. T

11. Replace bearing cups and cones if they are pitted, rough or damaged.
   - ❑ True ❑ False

11. T

CHAPTER 6
NON WHEEL-END SEALS

SKF seals have the lip material bonded to the metal shell (case). The bonding prevents leakage between the sealing lip and the shell, and it provides a longer lasting, more effective seal. This is different from the process used for assembled seals, in which assembly pressure is used to hold the lip in place between the metal parts.

A wide variety of sealing element (lip) materials is available. Each has its own unique characteristics. Selection should be made on the basis of application, compatibility with lubricants and fluids being retained, operating temperatures, and other conditions.

Synthetics

Today, the most popular and widely used sealing materials are synthetics. These include nitriles, polyacrylates, silicones and fluoroelastomers (Viton*). Each material has its own advantages and disadvantages.

Nitrile

Nitrile is the most popular material for the major applications today. It is actually a mixture of two basic synthetic rubbers, Buna and acrylonitrile polymers. Different properties are obtained by changing the percentage of each polymer used in the mixture (or copolymer).

Nitrile has generally replaced leather as a sealing lip material.

ADVANTAGES

+ Good oil/grease compatibility
+ Abrasion resistance
+ Good low temperature and swell characteristics
+ Good manufacturing qualities
+ Relatively low in cost

DISADVANTAGES

- Lacks compatibility with synthetic oils such as phosphate ester and Skydrol
- Not recommended with EP lubes at elevated temperatures

OPERATING RANGE

Standard SKF seals with nitrile sealing lips are effective in applications involving most mineral oils and greases in temperatures ranging from -40º to 250ºF (-40˚ to 121˚C).

IDENTIFICATION
Varies from gray-black to shiny jet black

SUBSTITUTE LIP MATERIALS
Polyacrylate, silicone or fluoroelastomer (See Seal Substitutions, page 53).

Duratemp (HNBR)
A special compound based on hydrogenated nitrile (HNBR) Duratemp offers improved tensile strength and resistance to heat, abrasion, hardening in hot oil, ozone and weathering effects. In some cases, aerated oils can be a problem for HNBRs.

OPERATING RANGE
Hydrogenated nitrile seals can be used from –40° to 300°F (-40° to 149°C).

ADVANTAGES
+ Tensile strength typically 50% higher than standard nitrile
+ Ozone and UV resistance considerably improved
+ Heat resistance increased 20% with less reduction in hardness and elongation, especially in hot oil with additives
+ Better abrasion resistance (equal to Duralip)

LIMITATIONS
- Decreased elasticity at cold temperatures
- Lower compression set resistance at cold temperatures (but better than Viton)
- Should not be considered a universal replacement for Viton especially considering attack by aerated lubricants and high temperature physical properties such as compression set

IDENTIFICATION
Visually the same as standard nitrile

SUBSTITUTE MATERIALS
Polyacrylate, Duralip and LongLife elastomers (depending on the applications)

Duralip

Duralip is SKF's special nitrile compound for extreme abrasion resistance. It is recommended where scale, sand, grit, dirt or other highly abrasive materials are present.

ADVANTAGES

+ Extreme abrasion resistance
+ See nitrile

DISADVANTAGES

- See nitrile

OPERATING RANGE

See nitrile

IDENTIFICATION

See nitrile

SUBSTITUTE LIP MATERIALS

See nitrile

Polyacrylates

Polyacrylates are elastomers that are compatible with higher operating temperatures, as well as extreme pressure (EP) lubricants. They are available in most general purpose designs.

ADVANTAGES

+ Good compatibility with most oils, including EP lubricants
+ High resistance to oxidation and ozone
+ Better compatibility with higher operating temperatures than nitrile

DISADVANTAGES

- Low compatibility with water and some industrial fluids
- Poor compression-set characteristics

OPERATING RANGE

Seals with polyacrylate lips are effective in temperatures ranging from -40º to 300ºF (-40 to 149˚C).

IDENTIFICATION
Generally black with same appearance as nitrile

SUBSTITUTE MATERIALS
Nitrile, silicone or fluoroelastomer (See Seal Substitutions, page 53).

Silicone
Silicone's high lubricant absorbency minimizes friction and wear. It can be used in a wide range of temperatures. Silicone seals are made only in bonded designs.

ADVANTAGES
+ High lubricant absorbency
+ Very flexible
+ Wide temperature range

DISADVANTAGES
- Poor compatibility with oils that have become oxidized, and EP lube additives
- Tendency to tear and cut during installation
- Poor abrasion resistance
- Relatively high cost

OPERATING RANGE
Silicone seals can withstand a very wide temperature range, from -100º to 325ºF (-73˚ to 163˚C).

IDENTIFICATION
Generally red or orange, but sometimes gray or blue. Silicone seals feel softer and are more flexible than other materials

SUBSTITUTE LIP MATERIALS
Fluoroelastomers, polyacrylate or nitrile (See Seal Substitutions, page 53).

Fluoroelastomers (Viton)
Fluoroelastomers are recommended for use with special lubricants and chemicals which cannot be handled by nitrile, polyacrylate or silicone. They are compatible with oils, chemicals, fuels and lubricants over a broad range of temperatures that are too extreme for other sealing elements.

Fluoroelastomers are available in standard line designs as well as large diameter seals. One fluoroelastomer, Viton, is compatible with aliphatic and aromatic hydrocarbons (carbon tetrachlorine, benzene, toluene, xylene) that are used as solvents for other rubbers.

Because of its compatibility with many different fluids over a broad temperature range, Viton also is effective in aircraft and space equipment applications.

ADVANTAGES

+ Wide temperature range
+ Low swell characteristics
+ Compatible with lubes, additives and chemicals that destroy other synthetic materials
+ Less downtime
+ Extreme abrasion resistance

DISADVANTAGES

- Relatively high cost

OPERATING RANGE

-40º to 400ºF (-40˚ to 204˚C)

IDENTIFICATION

Brown to black; may also be blue or green

SUBSTITUTE LIP MATERIALS

(See Seal Substitutions, page 53)

Other Synthetics

In addition to these standard materials, SKF can supply seals with elements molded of other materials for special conditions.

ADVANTAGES

+ Excludes dirt and dust well
+ Retains grease efficiently
+ High lubricant absorbency

DISADVANTAGES

- Cannot confine light oils
- May trap metal particles, causing shaft wear
- Absorbs water, which may cause shaft rusting

OPERATING RANGE

-65º to 200ºF (-54 to 93˚C)

SUBSTITUTE LIP MATERIALS

Nitrile, polyacrylate or fluoroelastomer (See Seal Substitutions, page 53).

Felt

Felt is another non-synthetic material which has long been used as a sealing material. Made of wool and sometimes laminated with synthetic rubber washers, felt is generally limited to light dirt exclusion. However, it effectively retains heavy lubricants such as wheel bearing grease and performs well in sparsely lubricated applications under some conditions such as small electric motors. Felt washers are available only in limited sizes.

ADVANTAGES

+ Excludes dirt and dust well
+ Retains grease efficiently
+ High lubricant absorbency

DISADVANTAGES

- Cannot confine light oils
- May trap metal particles, causing shaft wear
- Absorbs water, which may cause shaft rusting

OPERATING RANGE

-65ºF to 200ºF

SUBSTITUTE LIP MATERIALS

Nitrile, polyacrylate or fluoroelastomer (See Seal Substitutions, page 53).

Compound Selection Chart

The compatibility of sealing element materials with most fluids currently used can be found in the Compound Selection Chart in the SKF Handbook of Seals (Catalog #457010).

This chart rates the operation of different sealing materials (minor effect, moderate effect, static only, not recommended, insufficient data) within the range of specified operating temperatures and conditions for most common lubricants, fresh or salt water, and fluids.

Sealing Lip Performance

Following is a description of the lip itself and how it works. In this example, the Waveseal will be used. The Waveseal, SKF's preferred design, provides at least 30% more service life than other radial lip seals. A number of the toughest fleet applications specify this design to assure top performance and increased service life.

Waveseals®

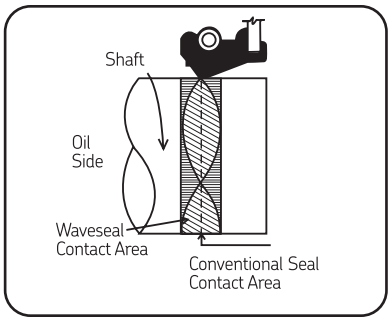
The SKF Waveseal features a sealing process utilizing hydrodynamics, that is completely different from that of conventional seals.

In technical terms, the Waveseal is a smooth lip, birotational hydrodynamic radial lip seal. More simply, it is a shaft seal that pumps lubricant back into the sump while sealing out contaminants – no matter which way the shaft is turning.

SKF's Scotseal PlusXL utilizes the patented waveseal design. This unique design continuously sweeps oil back to the bearings, keeping them running longer and stronger.

In terms of shaft and seal wear, the SKF Waveseal is important to truck operators because:

- It offers more dependable performance and up to 30% longer service life than conventional seals.
- It is the first standard line of shaft seals utilizing hydrodynamics.



The SKF Waveseal contacts a wider area of shaft than conventional seals. (fig. 1)

Waveseals vs. Conventional seals

In Chapter 2, the operation of a conventional shaft seal was explained. The Waveseal is completely different. The lip of a conventional seal rides the shaft in a narrow straight line. The Waveseal has a much broader contact (fig. 1).

When the Waveseal's specially molded lip contacts the shaft, it forms a sine wave (snakelike) pattern that moves back and forth on the shaft surface. The results are significant. Using a Waveseal produces less heat, provides better lubrication, and reduces shaft wear. It also lasts longer. Since the Waveseal does not depend on externally molded patterns, it does not lose pumping power as it wears.

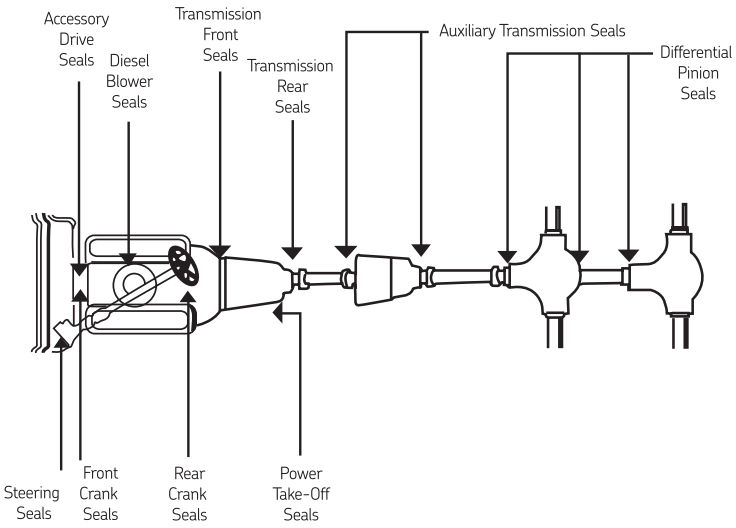
Compared to conventional seals, Waveseals:

- Generate 25-35% less heat at contact
- Produce 20% less frictional torque or drag
- Pump fluids back into the sump and ingest substantially less contaminants

*Viton is a registered trademark of E.I. DuPont.

Seal selection

Other than faulty installation, the most common reason a seal fails is that it is not the correct seal for the application. It is very important to check the old seal and replace it with one that is correct for the application.



Most often replaced seals (tractors, trucks, trailers, and buses) (fig. 2)

Replacement seals

If the old seal being replaced was manufactured by SKF, it should have one of four identifying numbers:

1. an SKF (or Chicago Rawhide) stock number
2. an older SKF industrial part number
3. an SKF drawing number
4. the original equipment manufacturer's part number

The SKF Master Interchange (Catalog #457012) lists the SKF stock numbers that correspond to nearly 150,000 shaft seals in use today.

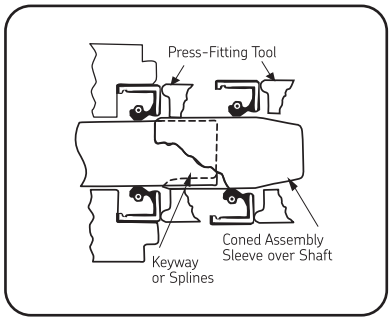
The simplest method of replacement is to use the number of the old seal. If this number is unreadable or unavailable, a replacement can be selected by matching sizes with listings in the SKF Handbook of Seals (Catalog #457010).

If there is no seal listed in exactly the same width, a narrower width is usually the best choice. A wider width is perfectly acceptable if space permits, however it is often limited.

Other applications

Installation procedures for transmissions, pinions, prop shafts, timing covers and other fleet seal applications are somewhat similar, but with these precautions:

- Seals should be press-fitted with a press-fitting tool and installation force should be applied as closely as possible to the outside edge of the seal.
- If a seal is installed into the housing bore with the shaft already installed, a sleeve-type or hollow fitting tool should be used to protect the lip as it is fitted over the shaft.
- Seals have flexible sealing members smaller than the shafts on which they function. When the shaft is assembled through the back of the seal, no special precautions are necessary other than removing nicks, burrs, and other rough spots from the shaft. The shaft end should be chamfered when it enters the seal against its lip.
- If the shaft is not tapered, or if a keyway or spline is present, a thin-wall coned assembly is recommended. Sharp spline and keyway edges should be covered with a lubricated assembly sleeve, shim stock or tape to protect the seal lip (fig.3).



A coned assembly sleeve may be used to protect the seal lip (fig. 3).

Seal substitutions

The SKF Handbook of Seals (457010) lists different seal designs which can be substituted for the old seal (within the limits of the operating conditions). Seal materials and proper substitutes were discussed throughout this chapter. Because of the importance of knowing and understanding these materials, they will be reviewed here.

If a lip material to match the old seal cannot be found in the size listings, refer to the Substitute Material Table in the Handbook of Seals. Some of the more common seal substitutions are listed below.

- Nitrile instead of felt
- Nitrile instead of leather
- Polyacrylate instead of nitrile
- Fluoroelastomer instead of polyacrylate
- Fluoroelastomer instead of silicone

Remember, colors other than black usually mean special materials. Materials should generally be substituted only if immediate replacement is more important than the assurance of maximum seal life. Because of the great number of factors involved, it is not always true that a premium elastomer will do a better sealing job than a less expensive material.

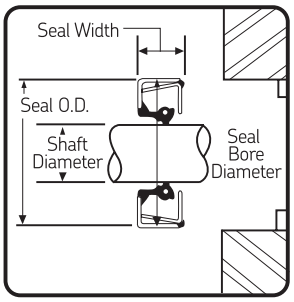
If the operating temperature is above 250ºF (121˚C), nitrile seals substituted for polyacrylate or silicone may have a shorter life. And, while silicone has a wider temperature range than polyacrylate, it breaks down if it is exposed to oxidized oils.

Seals for new applications

Choosing the right seal for a particular application depends on operating conditions:

1. Size
2. Speed
3. Pressure
4. Temperature/fluid compatibility

Each of these operating conditions should influence your selection of a seal for that application.



(fig. 3)

Size

Seal dimensions (fig. 3) used in seal selection include:

Seal bore diameter

This is the diameter of the hole into which the seal will be fitted.

Seal outside diameter (O.D.)

The O.D. is the seal's press-fit diameter. It is usually .004" to .010" larger than the bore so the seal will be held firmly in place.

Seal width

This is the overall width (including the inner and outer shells).

Shaft diameter

Because the seal's inside diameter is difficult to measure and varies with seal designs, the shaft diameter for which the seal was designed is used as the cataloged inside dimension.

Measuring the seal O.D.

When measuring the seal's outside diameter, measurements should be taken in at least three places equally spaced around the seal. The average of these readings can then be used as the diameter.

A vernier is used to measure the seal's I.D. (fig. 4)

How to measure seal I.D.

If you don't know the actual shaft diameter, you can estimate it by measuring the seal's inside dimensions.

It makes no difference if the seal has an inner shell or not. Simply average the three measurements of the lip inside diameter (fig. 4). Estimate shaft size as follows:

Estimated shaft diameter	Add to lip I. D.
Up to 1"	.031"
1" to 2"	.021" – .047"
2" to 6"	.047" – .063"
6" to 8"	.063" – .094"
8" to 12"	.125"

Speed

The maximum speed at which a seal can operate depends on other operating conditions. These conditions include shaft finish, pressure, temperature, eccentricity, the lubricant or fluid to be retained, and the particular design of the seal selected.

For instance, as shaft finish is improved (to the 10-20 micro-inch range) shaft speed can be increased. As shaft eccentricity (run-out) is reduced, shaft speed can be increased.

Surface speed at the contact point between the seal and the shaft (fpm: feet per minute) is generally a better indicator of seal performance than revolutions per minute (rpm).

To convert rpm to fpm, use the following formula or refer to the SKF Handbook of Seals (Catalog #457010).

.262 x rpm x shaft diameter (inches) = fpm

Pressure

The next aspect important to proper seal selection is pressure.

Allowable pressure goes down as shaft speed goes up.

The more pressure applied to a seal, the more lip surface contacts the shaft. More contact produces more friction and heat. Friction and heat rise as shaft speed increases. These factors cause faster wear and can shorten seal life.

Many of the bonded designs in the SKF Handbook of Seals can handle pressures of 15 psi at speeds up to 1,000 fpm. These can be found in the Handbook's table of operating conditions.

When speeds increase past 1,000 fpm, some of these same seals can handle only 5 psi.

Temperature/fluid compatibility

The final consideration affecting seal selection is temperature and fluid compatibility. Handbook listings are given in 16 "continuous" ratings – the relatively constant ambient temperature next to the seal, or the temperature of the lubricant it retains.

When operating conditions are under 0ºF (-18˚C) or above 200ºF (93˚C), the range recommended in the Handbook must be considered in selecting the type of sealing element material.

As was earlier stated, SKF's standard nitrile compound provides good service in most sealing applications from -65º to 250ºF (-54˚ to 121˚C). However, silicone, polyacrylate or fluoroelastomers provide safer operating limits and are preferred with higher or lower temperatures.

Summary

There are many factors involved in selecting seals. To avoid confusion, the SKF Handbook of Seals contains a Recommended Operating Conditions Selection Chart to assure a correct seal choice.

All of the selection factors are grouped together along with recommendations about the type of seal to use in almost every application.

Oil Seal Installation Instructions

1. **Check the bore** – The leading edge must be deburred. A rounded comer or chamfer should be provided.
2. **Check the shaft** – Remove surface nicks, burrs, grooves and spiral machine marks (machine lead).
3. **Check the shaft end** – Remove burrs or sharp edges. The shaft end should be chamfered in applications where the shaft enters the seal against the sealing lip.
4. **Check splines and keyways** – Sharp edges should be covered with a lubricated assembly sleeve, shim stock or tape to protect the seal lip.
5. **Check dimensions** – Be sure shaft and bore diameters match those specified for the seal selected.
6. **Check for parts interference** – Watch out for other machine parts that might rub against the seal and cause friction and damaging heat.
7. **Check the seal** – Damage may have occurred prior to installation. A sealing lip that is turned back, cut or otherwise damages should be replaced.
8. **Check seal direction** – Make sure that the new seal faces in the same direction as the original one. Generally, the lip faces the lubricant or fluid to be retained.
9. **Use the correct installation tools** – Press fitting tools should have an outside diameter approximately .010" (.254 mm) smaller than the bore size. For best results, the center of the tool should be open so that pressure is applied only at the outer edge.
10. **Pre-lubricate the sealing element** – Before installation, wipe the element with the lubricant being retained.
11. **Never hammer directly on the surface of the seal** – Use proper driving force, such as a softface tool, arbor press, or soft workplace (wood). Apply force evenly around the outer edge to avoid cocking the seal.
12. **Position the seal properly in the housing and inspect for alignment and installation damage.**

CHAPTER 6 REVIEW

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any of the questions. This learning technique assures more than four times the normal retention rate for even this technical subject.

1. SKF seals are available in a wide variety of sealing element materials and each has its own unique characteristics. Selection should be on the basis of _____.
   - ❑ a. application
   - ❑ b. compatibility with lubes and fluids
   - ❑ c. operating temperature
   - ❑ d. all of the above

1. D

2. Nitrile has generally replaced _____ as a sealing lip.
   - ❑ a. felt
   - ❑ b. silicone
   - ❑ c. leather
   - ❑ d. Viton

2. C

3. One of nitrile's disadvantages is that it is not compatible with _____.
   - ❑ a. oil
   - ❑ b. abrasion
   - ❑ c. synthetic oils
   - ❑ d. all of the above

3. C

4. One of polyacrylate's disadvantages is its _____.
   - ❑ a. low compatibility with water and some industrial fluids
   - ❑ b. high resistance to oxidation and ozone
   - ❑ c. relatively high cost
   - ❑ d. good compression-set characteristics

4. A

5. Silicone's advantages include its _____.
   - ❑ a. high lube absorbency
   - ❑ b. good flexibility
   - ❑ c. ability to handle a wide temperature range
   - ❑ d. all of the above

5. D

6. Seals made of fluoroelastomers _____.
   - ❑ a. are inexpensive
   - ❑ b. sometimes require special molds
   - ❑ c. lack wide temperature range resistance
   - ❑ d. are compatible with aggressive oil

6. D

7. Felt is a non-synthetic material which has long been used as a sealing material. Its advantages include _____.
   - ❑ a. excellent water resistance
   - ❑ b. good exclusion of dust and dirt
   - ❑ c. tends to smooth rough shaft surfaces
   - ❑ d. good oil retention

7. B

8. Using a Waveseal produces significant results which include _____.
   - ❑ a. less heat produced
   - ❑ b. less shaft wear
   - ❑ c. better lip lubrication
   - ❑ d. all of the above

8. D

9. A replacement seal manufactured by SKF is identified by _____.
   - ❑ a. an SKF stock number
   - ❑ b. an SKF drawing number
   - ❑ c. the original equipment manufacturer's part number
   - ❑ d. any of the above

9. D

10. Choosing the right seal for an application depends on _____.
   - ❑ a. seal dimensions
   - ❑ b. speed and pressure
   - ❑ c. temperature
   - ❑ d. all of the above

10. D

11. A substitute material for silicone is _____.
   - ❑ a. felt
   - ❑ b. leather
   - ❑ c. nitrile
   - ❑ d. none of the above

11. C

12. Nitrile seals will have shortened lifespans if the operating temperature is _____ 250ºF.
   - ❑ a. below
   - ❑ b. above
   - ❑ c. at
   - ❑ d. none of the above

12. B

13. _____ is the seal's press-fit diameter; usually .004" to .008" larger than the bore.
    - ❑ a. Shaft diameter
    - ❑ b. Seal outside diameter
    - ❑ c. Seal inside diameter
    - ❑ d. Bore diameter

13. B

14. The most popular and versatile sealing materials in use today are synthetics, such as nitrites, polyacrylates, silicones and fluoroelastomers.
    - ❑ True ❑ False

14. T

15. Nitrite is the most popular material for the majority of sealing applications today.
    - ❑ True ❑ False

15. T

16. One of Vitons disadvantages is its poor resistance to temperature extremes.
    - ❑ True ❑ False

16. F

17. Polyacrylates are elastomers that work well with high operating temperatures and EP lubricants.
    - ❑ True ❑ False

17. T

18. Polyacrylates have high resistance to water.
    - ❑ True ❑ False

18. F

19. The lip of a Waveseal rides the shaft in a straight-line pattern.
    - ❑ True ❑ False

19. F

20. The maximum speed at which a seal can operate depends on other operating conditions. These conditions include: .
    - ❑ a. the design of the seal selected
    - ❑ b. the lubricant or fluid to be retained
    - ❑ c. pressure and temperature
    - ❑ d. all of the above

20. D

21. A thin-wall coned assembly sleeve is recommended when _____.
    - ❑ a. the shaft is not tapered
    - ❑ b. a keyway is discovered
    - ❑ c. a spline is present
    - ❑ d. all of the above

21. D

22. If the seal has no identification numbers, you should average three measurements of the _____.
    - ❑ a. seal width
    - ❑ b. seal bore
    - ❑ c. lip inside diameter
    - ❑ d. any of the above

22. C

23. A common reason for seal failure is that it is not the right seal for the application in the first place.
    - ❑ True ❑ False

23. T

24. If there is no seal listed in the exact same width in the SKF Handbook of Seals, a narrower width seal may be used.
    - ❑ True ❑ False

24. T

25. Substitutions should be used only when immediate use is more important than the assurance of maximum seal life.
    - ❑ True ❑ False

25. T

26. Using a seal with a premium elastomer lip will always do a better job than a less expensive material.
    - ❑ True ❑ False

26. F

27. Seal bore is the diameter of the hole into which the seal will be fitted.
    - ❑ True ❑ False

27. T

28. Seal width is the width of the inner shell only.
    - ❑ True ❑ False

28. F

29. The outside diameter can be measured by taking one reading around the seal.
    - ❑ True ❑ False

29. F

30. If the actual shaft diameter is unknown, you can estimate the shaft diameter by measuring the seal's outside dimensions.
    - ❑ True ❑ False

30. F

31. Use a sleeve-type or hollow fitting tool when installing a seal into the housing bore of a pinion with the shaft already inserted.
    - ❑ True ❑ False

31. T

32. Seals are press-fitted in transmissions by applying force as close as possible to the inside edge of the seal.
    - ❑ True ❑ False

32. F

CHAPTER 7
WEAR SLEEVES

Continuous contact between a rotating shaft and a seal always causes shaft polishing friction. Under normal operating conditions, the friction causes a slight wear track on the shaft.

But, as operating conditions worsen, shaft wear can accelerate. Heat, dirt, excessive speed, lack of lubrication, eccentricity or a cocked seal can produce a deep groove on the surface. The ultimate result is a leak.

If this groove can be felt with a paper clip or with your finger nail, it has become too deep to accommodate a replacement seal without leaking.

There are three solutions:

1. Reworking or remetalizing the shaft surface at a machine shop – High cost, requires hours of fleet downtime.
2. Replacing the shaft – Also expensive, with substantial fleet downtime.
3. Installing a wear sleeve – Comparatively low in cost with virtually no downtime.

The Speedi-Sleeve repairs damaged shafts efficiently (fig. 1).

When it comes to correcting yokes, flanges and shafts, a wear sleeve requires the least amount of downtime and cost. Applied over the damaged shaft, it makes the shaft usable again, eliminates shaft leaks, and smooths out damaged surfaces – all faster and less expensive than re-metalizing or replacing the shaft.

SKF offers one special type of wear sleeve designed for even more efficient shaft repair – Speedi-Sleeves (fig. 1).

Speedi-Sleeves

Speedi-Sleeves offer fleet operators a way to quickly repair worn shaft surfaces right in the garage. Downtime is reduced since installation takes only a few minutes, often without removing the shaft.

There is no resizing of the seal. Unlike conventional thick sleeves, Speedi-Sleeves use the original size seal. No matter whether the Speedi-Sleeve is used on a crankshaft, transmission, or pinion, both labor and hard parts inventory costs are substantially reduced.

Speedi-Sleeves are precision-made of ultra-thin, stainless steel. Once installed, it provides a new leakproof barrier and a long-lasting wear surface for the new seal that can outlast the original shaft finish.

ADVANTAGES

+ Corrects crankshaft, pinion, and transmission surfaces
+ Repairs yokes, flanges and shafts
+ Can be used without changing the seal size or part number
+ Requires little downtime

Each sleeve is built with a removable flange and includes a special tool for installation. This tool is placed over the Speedi-Sleeve. Both the tool and sleeve are tapped into position on the shaft, yoke or flange.

The flange on the Speedi-Sleeve allows the sleeve to be pulled-on instead of pushed-on, eliminating sleeve distortion.

When the Speedi-Sleeve is positioned, the tool slides off easily. The flange can be left intact, or cut and peeled off along a pre-cut line.

Speedi-Sleeves fit seal-worn end yokes (fig. 2), steering gear shafts, front and rear crankshafts and almost every part from almost every manufacturer represented in your rigs.

Speedi-Sleeves fit seal-worn end yokes (fig. 2).

It takes only a few Speedi-Sleeves to meet the needs of even the biggest operators. In most cases there's no need to stock more than one size sleeve for each seal application or location.

Re-sleeving can be part of the fleet's regular preventive maintenance schedule. It takes little time to tap on a Speedi-Sleeve when the rig is already in for replacement of seals and bearings, or when a shaft is disassembled for general service.

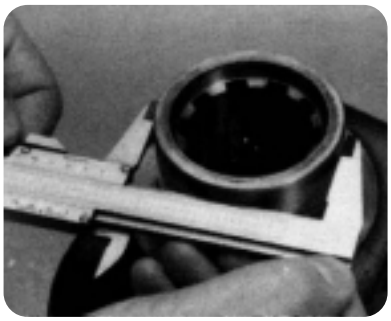
Speedi-Sleeve Gold is so technologically superior it delivers a surface hardness of 2300 Vickers (approximately 80-85 HRc). This hardness means abrasive dirt and grit tend to roll off of the surface, rather than digging into it.

Speedi-Sleeve Gold has been thoroughly tested for its abrasion resistant qualities in a severe dust environment test using both coarse and fine sand. Temperatures were elevated to 225˚F and shaft speeds were cranked up to 1,700 fpm. Under these conditions, shafts without Speedi-Sleeve protection showed leakage at 450 hours, on average. Speedi-Sleeve Gold protected shafts ran to an average of 2,500 hours.

Currently, Speedi-Sleeve Gold is available in 50 sizes that cover the majority of common shaft sizes. Other sizes up to eight inches in diameter, are available in quantity as special orders.

Speedi-Sleeve installation

Speedi-Sleeves are available for shaft diameters ranging from .498" to 8.005". Each sleeve kit contains a disposable installation tool and is marked with the shaft range for proper selection. Follow these guidelines for proper Speedi-Sleeve installation:



Take three measurements to average shaft diameter (fig. 3).

1. Clean the surface where the seal contacted the shaft. File down and polish any burrs or rough spots.
2. Measure the diameter where the sleeve will be positioned on an unworn portion of the shaft. Measure in three positions and average the reading, in case the shaft is out of round (fig. 3). If the average diameter is within the range for a given Speedi-Sleeve, there is sufficient press-fit built into the sleeve to keep it from sliding or spinning. No cement is necessary.
3. If the groove does not require filling, apply a light layer of non-hardening sealant to the inner surface of the sleeve.
4. If the shaft is deeply scored, fill the groove with powdered metal epoxy type filler. Install Speedi-Sleeve before the filler hardens.
5. Undersize shafts: Shaft diameters a few thousandths under the published minimum may be sleeved if cement is used.
6. Oversize shafts: Diameters larger than the published maximum can be sleeved if first machined with a finish 125 rms or better. Note that the use of Speedi-Sleeve eliminates the need for special grinding or preparation of the surface.
7. Speedi-Sleeves are wide enough to cover the wear pattern of both standard and wider combination seals. Where extra wide combinations are encountered, a second sleeve can be installed to butt against the first. The flange is then peeled off to provide the clearance necessary for the seal housing to slide into place. The Speedi-Sleeve installation flange can be left in place as an oil flinger to prevent surges of oil from being pumped into the seal lip by the action of the adjacent bearing.

8. Determine how far back the sleeve must be positioned to cover the old seal wear tracks. Measure to the exact point, or mark directly on the surface.
9. The sleeve must be placed over the worn area, not just bottomed or left flush with the end of the shaft.
10. Drop the Speedi-Sleeve into the end of the installation tool so only the flange end projects. The flange end of the sleeve goes on the shaft first. Gently pound the center of the tool until the sleeve reaches the point marked (fig. 4).
11. Speedi-Sleeves may be installed to any depth required. If the installation tool supplied with sleeve is too short, a length of pipe with a squared-off, burr-free end can be substituted. Inside pipe diameters should be larger than the shaft by:

Shafts less than 3":	1/32" to 1/8"
Shafts 3" to 6":	1/32" to 3/16"
Shafts more than 6":	3/64" to 7/32"

12. If clearance is needed, the Speedi-Sleeve flange can be removed easily with side cutters and pried away. The flange will peel off along a pre-cut line (fig. 5).

Tap the tool until the sleeve is positioned properly (fig. 4).

Peel off the flange along the pre-cut line (fig. 5).

CHAPTER 7 REVIEW

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any of the questions. This learning technique assures more than four times the normal retention rate for even this technical subject.

1. _____ can cause a seal lip to groove the shaft.
   - ❏ a. Dust, heat and dirt
   - ❏ b. Lack of lubrication
   - ❏ c. A cocked seal
   - ❏ d. All of the above

1. D

2. The Speedi-Sleeve is an ultra-thin wear sleeve made of _____.
   - ❏ a. bronze
   - ❏ b. stainless steel
   - ❏ c. zinc
   - ❏ d. magnesium

2. B

3. Applying a wear sleeve over a damaged surface can _____.
   - ❏ a. eliminate shaft leaks
   - ❏ b. make the shaft usable again
   - ❏ c. smooth out damaged surfaces
   - ❏ d. all of the above

3. D

4. Speedi-Sleeves can be used on _____.
   - ❏ a. transmissions
   - ❏ b. pinions
   - ❏ c. front and rear crankshafts
   - ❏ d. all of the above

4. D

5. If the shaft is deeply scored, the groove should be _____.
   - ❏ a. filled with an epoxy type filler
   - ❏ b. filed down to a smooth surface
   - ❏ c. lubricated with oil
   - ❏ d. all of the above

5. A

6. The inside diameter of a pipe used to install a 4" Speedi-Sleeve should be _____ larger than the shaft.
   - ❑ a. at least 1/2"
   - ❑ b. less than 1/2"
   - ❑ c. 1/32" – 3/16"
   - ❑ d. 3/4"

6. C

7. When a seal groove on a shaft can be felt with a fingernail or paper clip, it must be repaired.
   - ❑ True ❑ False

7. T

8. Shaft wear can accelerate as operating conditions worsen.
   - ❑ True ❑ False

8. T

9. Continuous contact between a seal and rotating shaft will always cause shaft polishing friction.
   - ❑ True ❑ False

9. T

10. A deeply scored shaft can only be corrected by remetalizing the surface or replacing the shaft.
    - ❑ True ❑ False

10. F

11. Installing a Speedi-Sleeve is expensive and requires substantial downtime.
    - ❑ True ❑ False

11. F

12. The first step to Speedi-Sleeve installation is removal of the shaft.
    - ❑ True ❑ False

12. F

13. The surface of the Speedi-Sleeve can actually outlast the original shaft surface.
    - ❑ True ❑ False

13. T

14. When installing a Speedi-Sleeve over a shaft, the original size seal can still be used.
    - ❑ True ❑ False

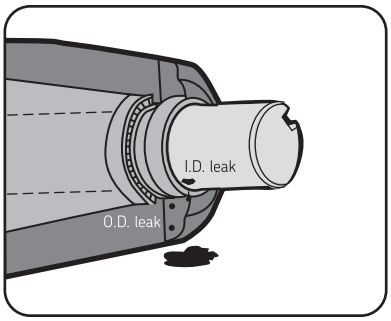
14. T

15. Each Speedi-Sleeve is built with a removable flange and includes a special tool for installation.
    - ❑ True ❑ False

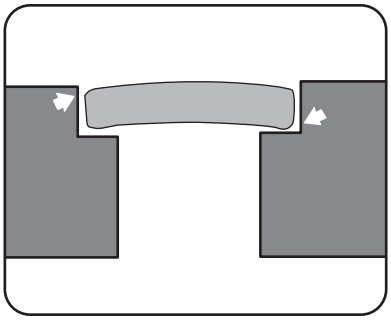
15. T

CHAPTER 8
TROUBLESHOOTING SHAFT SEALS AND SCOTSEALS

You now know the various types of seals available, can select the right seal for the right application, and are able to install it. But before you replace that next seal, there are some troubleshooting points that will round out your knowledge of seals.



Check the seal area for leaks (fig. 1).



This seal was cocked during installation (fig. 2).

Shaft seals

Preliminary survey

The best way to troubleshoot is to follow a sequence of steps that should lead you to the problem.

1. What was the seal supposed to do? How well has it done the job in the past? If there is a history of failures, the problem may not be caused by the seal itself.
2. Was it the right seal? Check the seal's part number and look up its recommended applications. If the correct seal has been installed and there is no history of repeated failures, the problem requires further investigation.
3. Pinpoint the source of the leak. It may be either an I.D. leak or an O.D. leak. Also, find out when the leak first occurred and see if this relates to a change in maintenance or operating procedures (fig. 1).

Investigate clues

Seal markings

The two areas that should be thoroughly checked are the seal outer diameter (O.D.) and the seal inner diameter (I.D.). Tell-tale marks on either of these areas can give you a good idea of why the seal failed.

The solution

The first surface to check is the O.D. If the seal has been properly installed, the press-fit markings will be fairly uniform and straight.

Cocked seal

Markings also can be tell-tale signs that the seal was cocked during installation.

Light scratches on the front of the seal would appear when the seal was first inserted. Since the seal was cocked, it takes additional force to seat the back half. This extra force causes heavier markings on the back of the seal (fig. 2).

The solution

If the seal is cocked, you have only one solution. Remove it and put in a new one, but be sure it's straight.

Lip wear patterns

Look for clues in the sealing member of the seal. A small cut or nick could be the source of the leak. But if everything looks intact, it's time to look at the wear pattern of the lip.

A new seal that has never been installed has a sharp edge on its sealing lip at the contact point. Following a period of normal operation, the lip's sharp edge will be flattened some by normal wear. If the lip has been substantially worn away, the seal may not be getting enough lubrication, the shaft may be corroded, or the finish too rough. Extreme wear could also be caused by shaft-whip.

If you find a leaking seal with a wide wear band on one side, but a narrow band on the other, you can suspect high STBM (shaft to bore misalignment); unless O.D. markings indicated the seal was cocked. The lip area with the greatest wear indicates the direction of shaft misalignment.

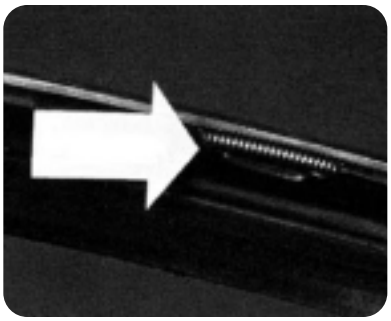
Initial leakage will generally occur in the area that shows little or no seal wear. This is because of inadequate lip contact. But as the worn side is hardened from excess pressure and heat, it may crack and cause additional leakage.

The solution

Check the shaft-to-bore alignment. Correct the alignment.

Operating pressure

Excess pressure can crush the lip against the shaft. Heavy friction will eventually force the garter spring through the lip. Excess pressure can blow the lip completely off (fig. 3).



Excess pressure can blow the lip off (fig. 3).

The solution

We recommend two ways to prevent seal failure caused by medium pressure.

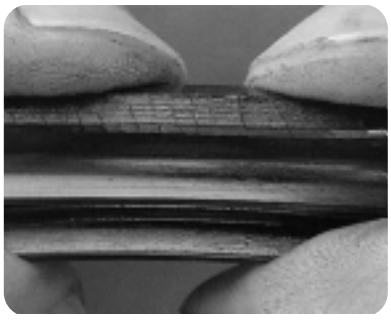
First, check all the air vents. Dirt or paint may block proper air flow. Second, if the system is clean, try using a high pressure seal such as the CRW5 and CRWA5.

Excessive temperature

The condition of the sealing element can also tell us about temperature conditions. If the lip is hardened and brittle with many cracks in its surface, overheating is probably the cause (fig. 4).

A seal lip gradually hardens as it ages, but it should remain flexible if temperatures do not exceed the recommended maximums for the sealing material.

Sometimes heat is high enough to break down the oil, but not hot enough to harden the lip. In this case, sludge accumulates and is deposited on the seal lip.



Overheating can cause cracks on the seal surface (fig. 4).

The solution

When a sludge deposit cracks or breaks off, leakage paths are created. A change in seal material or design will do little to improve sealing performance. Instead, find a lubricant that is more stable at high temperatures. Either that, or try to reduce the operating temperature.

Incorrect lubricant

A modern lubricant may employ many chemicals to improve its performance. Unfortunately, additives that improve the lube may adversely affect the seal.

Disulfide additives, for example, give lubricants anti-wear properties, but they also cure or harden the sealing element. Many EP (extreme pressure) lubes have additives that become more active as they heat up. They also become more harmful to the seal.

The solution

When the sealing member softens with use, or when there is not sufficient overheating to explain the hardening you observe, the problem could be that the lubricant and seal are incompatible. The remedy is to go back to the SKF Handbook of Seals (457010) and check seal material/fluid compatibility specifications.

Case still unsolved?

If none of the clues discussed so far are present, there still are a few things that you can do:

- Check for foreign particles that may be temporarily trapped under the lip.
- If it's a spring-loaded seal, check to see if the garter spring is still intact.

- A small nick or cut hardly visible to the eye may turn an otherwise good seal into a leaker. Look for this type of damage when leakage in slight.
- Compare the fit of a failing seal with a new seal on the same shaft. If it feels loose but is unworn, the cause may be swelling - a reaction to the fluid being sealed. Check the compatibility rating in the SKF Handbook of Seals (457010).

Scotseals failure analysis

Failure analysis of prematurely failed seals is one of the best means to discover the cause of failure and to avoid a similar fate for the replacement seal.

The cross sectional drawings at right illustrate the critical components of each member of the **Scotseal**® family. The captions identify these components as described in the following pages.

For **Scotseal**® **PlusXL**, failures most likely result from these common errors:

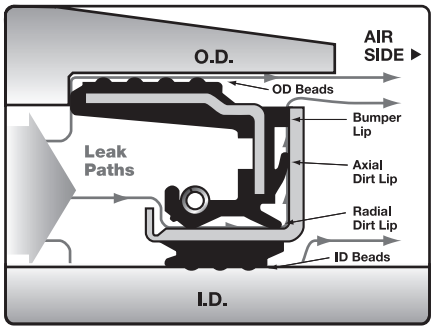
- Improper installation
  – O.D. and/or I.D. not lubed
- Lube contamination
- Spindle not fully prepped
- Use of a hammer

Note: replacing a narrow footed seal like the **Scotseal**® **Classic** and **Scotseal**® **Longlife** requires cleaning the spindle along the new area where the wider **Scotseal**® **PlusXL** will sit.

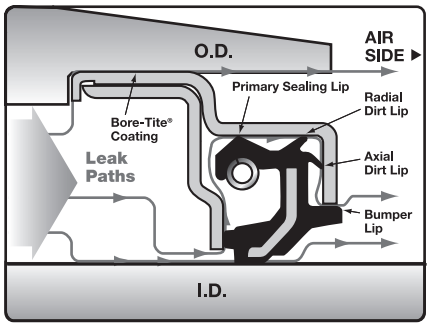
Below are the key failure modes for **Scotseal**® **Classic** and **Scotseal**® **Longlife**. These account for the lion's share of premature seal failures.

- **Improper installation**
  Wrong or no tool used
- **Cocked installation**
- **Lubricant contamination**
  Metal flakes
  Dirt or water
  Mixing of lube types
- Improper bearing adjustment
- Seal spinning on spindle
  Damaged spindle
- Hub imperfections
- Installed over a wear ring

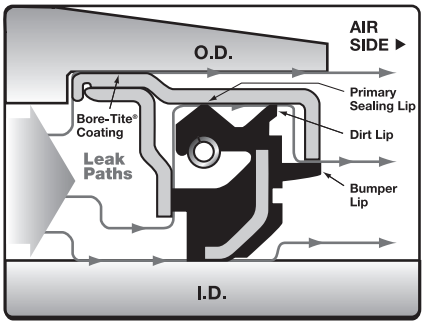
Scotseal® **PlusXL**



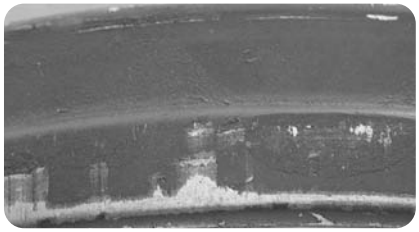
Scotseal® **Longlife**



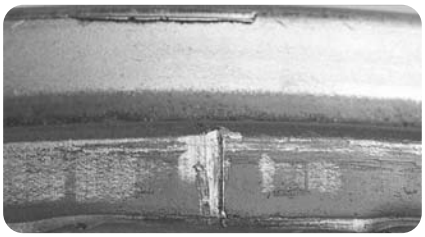
Scotseal® **Classic**



Consult the following pages for examples of Failure Analysis.



(fig. 1)



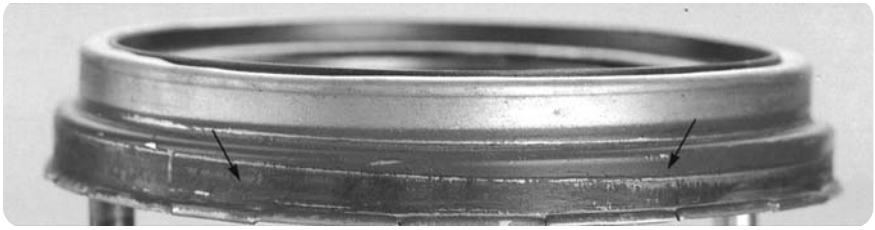
(fig. 2)

Scotseal® *Classic* / **Scotseal®** *Longlife*

External inspection – outer diameter

Normal scuffing: The surface will show some scraped areas, that's normal. But signs of nicks, scratches metal particles, or any foreign material are warning flags that something else is amiss. Make sure the hub bore is smooth and free of burrs or nicks (fig. 1).

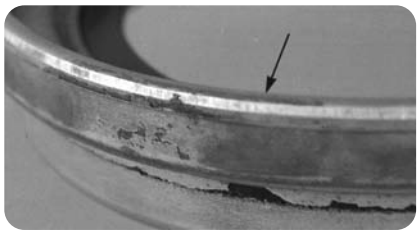
O.D. radial grooves: If the Bore-Tite® film has been scored all the way across the width of the seal, you should inspect the hub for burrs or damage. Before installation, the hub should be inspected and cleaned with emery cloth or a fine file (fig. 2).



(fig. 3)

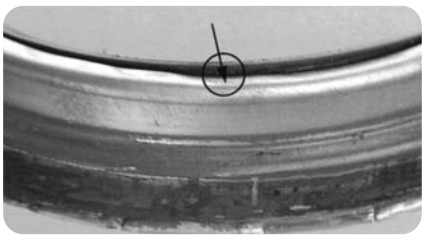
If you see lines around the seal, several things could have happened. If the lines are etched to the metal, the seal could have spun as a result of being the wrong application or, more likely, it was installed crooked or cocked.

As you can see in this example, the grooves run from high on the right to low on the left, indicating a cocked installation. Most likely, the seal was not properly "bottomed-out" or a centering tool was not used – common causes of premature seal failure (fig. 3).



(fig. 4)

Shiny leading edge: Occasionally someone will try to improve seal installation by changing the shape of the seal. They'll round off the leading edge of the outer cup on a grinder. This distorts the outer diameter and can possibly cause the seal to disassemble (fig. 4).

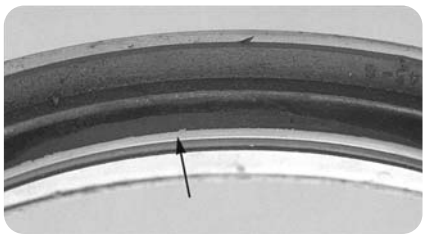


(fig. 5)

Outer cup damage: If you see dents, nicks, or a bent casing you can bet that the seal was installed without the proper tool or the tool was damaged. Gashes indicate the use of a sharp object, like a screwdriver or punch (fig. 5).

External Inspection – inner diameter

I.D. wear: If the I.D. of the packing is shiny, or has axial scratches, the seal has spun on the shaft. That can be caused by not bottoming-out the seal properly, leaving it cocked in the bore or installing the wrong part number (fig. 6).

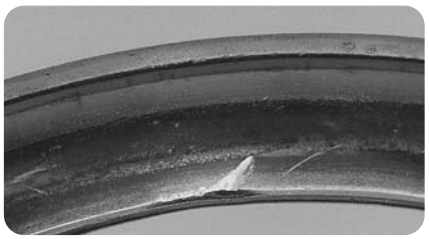


(fig. 6)

Installed backwards: The only way that the packing can be worn shiny, as shown here, is by rubbing against the bearing race. The only way that can happen is by putting the seal in backwards. The Scotseal® installation poster makes a convenient guide (fig. 7).

(fig. 7)

Severely damaged I.D.: Scratches or dents in the I.D. are signs that the seal has struck the spindle or axle tube during installation. Rushing the installation and not lining up the wheel dolly is the usual suspect. Or a rough shop floor may be the problem (fig. 8).

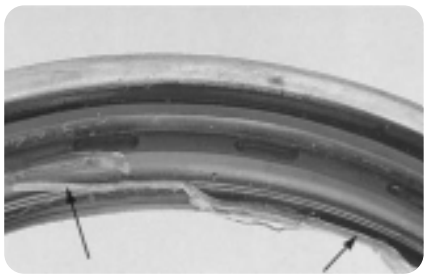


(fig. 8)

Distorted packing: One way to damage the packing of a Scotseal® is to try to install it over a wear ring. The wear ring will deform the inner surface and ruin the seal. Any previously installed wear ring must be removed prior to installing a Scotseal (fig. 9).

(fig. 9)

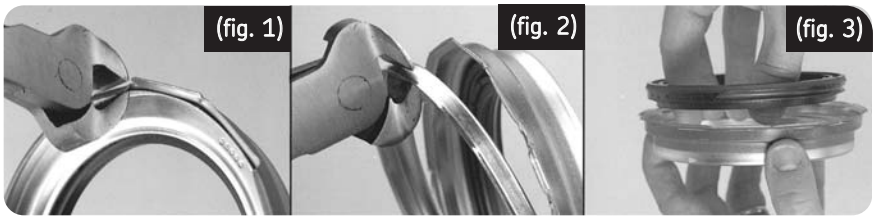
Foreign matter on I.D.: Occasionally, you will come across a seal with a shaft leak that has a mysterious, tacky substance on it. Most likely someone added a silicone sealant to "improve" the seal. Old habits die hard (fig. 10).



(fig. 10)

External inspection – outer diameter

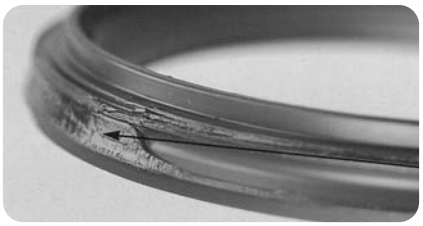
Opening a Scotseal



Use pliers or end cutters and work your way all the way around the seal, straightening the outer cup flange (fig. 1).

Remove the inner cup. Be sure to wear gloves or use a shop rag to protect your hands, as the open flange edges are sharp (fig. 2).

Remove the packing without disturbing the lip surfaces, as shown (fig. 3).

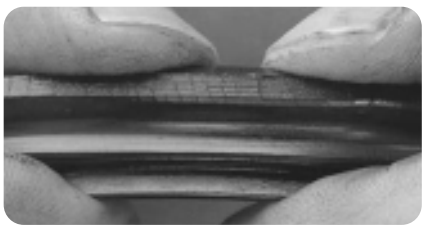


(fig. 4)

Factory Applied Grease

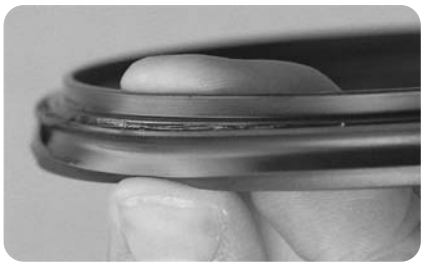
Internal inspection – The major clues

Lip grease: Every Scotseal® comes with grease between the primary and dirt lip. If it's not there, it's very likely oil has washed it away. Suspects are excessive end-play, a cocked seal or improper ventilation of the wheel end (dirt, corrosion or paint-plugged vent) (fig. 4).



(fig. 5)

Brittle primary seal lip: After cleaning the entire seal, use your fingers to curl the primary seal lip back. Run your finger completely around the circumference. The oil lip should be smooth and pliable. If not, the seal has overheated; lack of lubrication could be the cause (fig. 5). Lack of lubrication may have fried the bearings as well.



(fig. 6)

Broken dirt lip: Using the same technique, check the dirt lip. If it's dry and brittle, most likely it's been baked. It will probably split away from the seal at some point around the circumference (fig. 6).

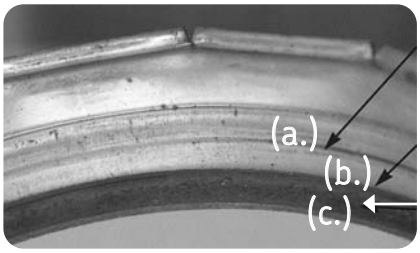
Internal inspection – wear tracks

Good pattern: What you will see in a good Scotseal® are the two parallel lines that look like they've been drawn with a sharp pencil. They're approximately the same size and equidistant from the edge all the way around the inside of the outer cup (fig. 7).

Wide, wide: If both lines are wider than pencil lines, it means that the primary lip and dirt lip have been allowed to move in and out on the outer cup. The cause of this is excessive endplay, indicating that the bearing adjustment is greater than .001"and .005" (fig. 8).

Metal shavings in lip area: Before cleaning the seal, inspect the seal area for traces of metal particles. A magnet can attract metal particles. Sharp edges of metal may have cut the seal primary lip causing the seal to leak (fig. 9).

Cocked seal – inner markings: Holding the outer cup just below eye level and flat, like a bowl, rotate your wrist through 360°. If the seal has run cocked, the two lines will be parallel to each other, but they appear to move closer and then farther from the outer cup flange (fig. 10).

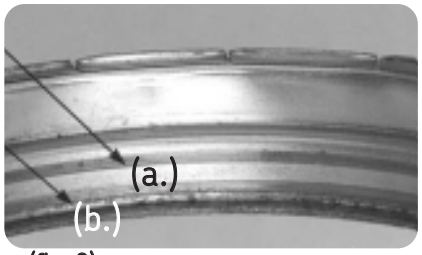


(fig. 7)

a. Primary Lip Wear Pattern

b. Dirt Lip Wear Pattern

c. Contamination Being Excluded



(fig. 8)

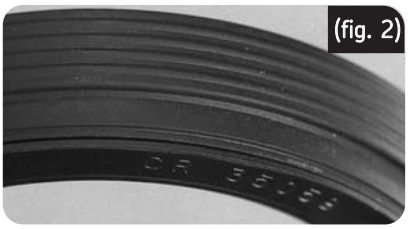
a. Primary Lip Wear Pattern

b. Dirt Lip Wear Pattern

(fig. 9)

(fig. 10)

(fig. 1)


(fig. 2)

(fig. 3)

(fig. 4)

(fig. 5)

(fig. 6)

Scotseal® *PlusXL*

External inspection – checking the beads

Normal exterior: The tough HNBR material covering on the Scotseal®PlusXL doesn't supply clues as readily as Bore-Tite does. But it can still reveal problems and lead to corrective measures. There should be lubrication residue in each of the O.D., I.D. beads (fig. 1).

Dry exterior: If, in good illumination, you cannot see any residual lubrication between the beads of the outer sleeve, the seal may have been installed dry. A Scotseal®PlusXL does not need special tools, but it does need lubrication for proper installation (fig. 2).

Damaged O.D. beads: If the external ridges appear damaged, most likely someone has tried to force the seal in place without proper lubrication. Burrs or dirt in the bore can also cause problems, but they're not as visible with the thick HNBR rubber protection (fig. 3).

Worn I.D. beads: A worn I.D. indicates the seal has been slipping on the spindle. Look for three main causes: a cocked seal, a bent seal section, or poor spindle preparation in changing from another seal to the Scotseal®PlusXL (fig. 4).

Damaged I.D. beads: Cuts or scarring in the I.D. is caused by jamming the seal into the spindle or axle tube. Misaligning the wheel dolly is usually the result of haste, however the work area should be checked to make sure the floor is smooth and free of clutter (fig. 5).

Dented, scarred sleeve assembly: A dimpled or dented surface indicates damage caused by a problem during installation. The use of hard-faced tools or seal driver is the most likely culprit (fig. 6).

Opening a Scotseal® PlusXL

Use pliers to straighten the flange on the sleeve section. Be sure to wear gloves or use a shop rag to protect your hands. The opened flange is extremely sharp (fig. 1).

Pull the two components apart. Then set the sleeve assembly aside (the top component shown above). Place it carefully where it is out of the way, but won't be disturbed (fig. 2).

Internal inspection – sealing lip condition

Check for grease: Locate the primary sealing lip and radial dirt lip. If the area between them is dry, something has allowed oil to wash away the grease. The cause could be excessive end-play or a cocked seal. Or internal pressure from a blocked vent (fig. 3).

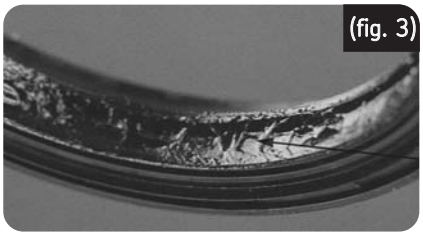
Normal lip flexibility: Check the primary sealing lip and dirt lips by pressing downward on them with your thumbs, sliding them around the entire circumference. The rubber should remain soft and flexible in normal use (fig. 4).

Cracked lips: If, when you check the primary and dirt lips the lip feels rough and dry, it has probably been subjected to excessive heat. Loss of lubrication is one of the prime suspects (fig. 5).

Flattened bumper lip: Scale or rust on the spindle will prevent the wider Scotseal®PlusXL from sealing properly. This creates extra pressure on the bumper and axial dirt lips. The spindle must be fully cleaned and all wear rings removed before installing a Scotseal® PlusXL (fig. 6).

(fig. 1)

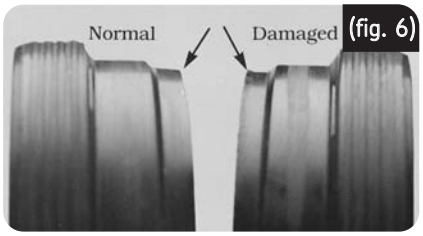
(fig. 2)


(fig. 3)

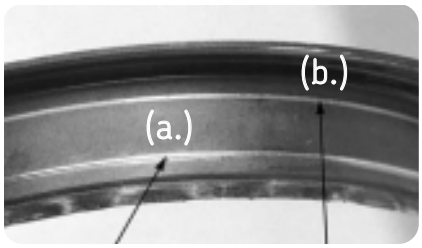
Factory Applied Grease

(fig. 4)

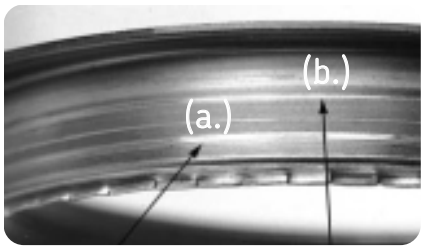
(fig. 5)



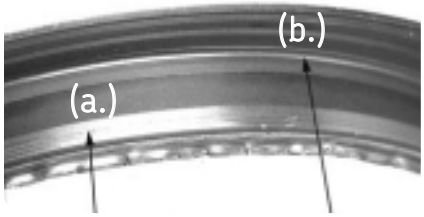
(fig. 6)



(fig. 1)



(fig. 2)



(fig. 3)

a. Primary Lip Wear Pattern

b. Radial Dirt Lip Wear Pattern

External inspection – primary and radial dirt lip wear patterns

Good primary lip pattern: You should see two parallel lines. The primary lip line is slightly wider than the radial lip marking, because it's an SKF Waveseal® design (fig. 1).

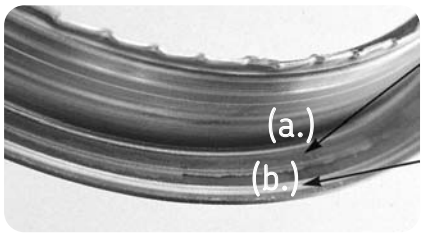
Wide, wide: If both of the tracks formed by the primary and dirt lips are wide, chances are the whole wheel assembly is moving in and out at an excessive rate. End-play like this causes leaks as well as increased tire wear. The solution, of course, is proper bearing adjustment (fig. 2).

Wide, thin: If the primary seal lip line (bottom) is extra wide, while the radial dirt lip line (top) is light, there is excessive pressure on the primary lip. For steer and trailer axles that can be a plugged vent, on drive axles the tube vent may be locked (fig. 3).

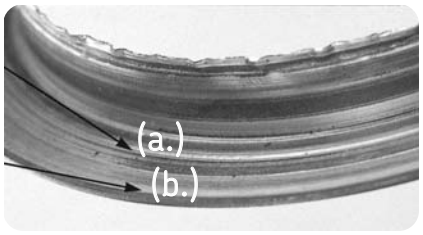
Internal inspection –

Good axial and bumper lip patterns: When you examine the axial face, you have two more wear patterns to learn from. About half way up on the face you should see a pencil line track from the axial lip, and at the top edge a gently scuffed pattern from the bumper lip (fig. 4).

Wide, shiny: If both lines are wide or polished clean, then you should suspect that the seal has been compressed. This will happen if the I.D. of the seal isn't lubricated before installation, if the sleeve wasn't sealed fully on the spindle, or if the bearing adjustment is too tight (fig. 5).



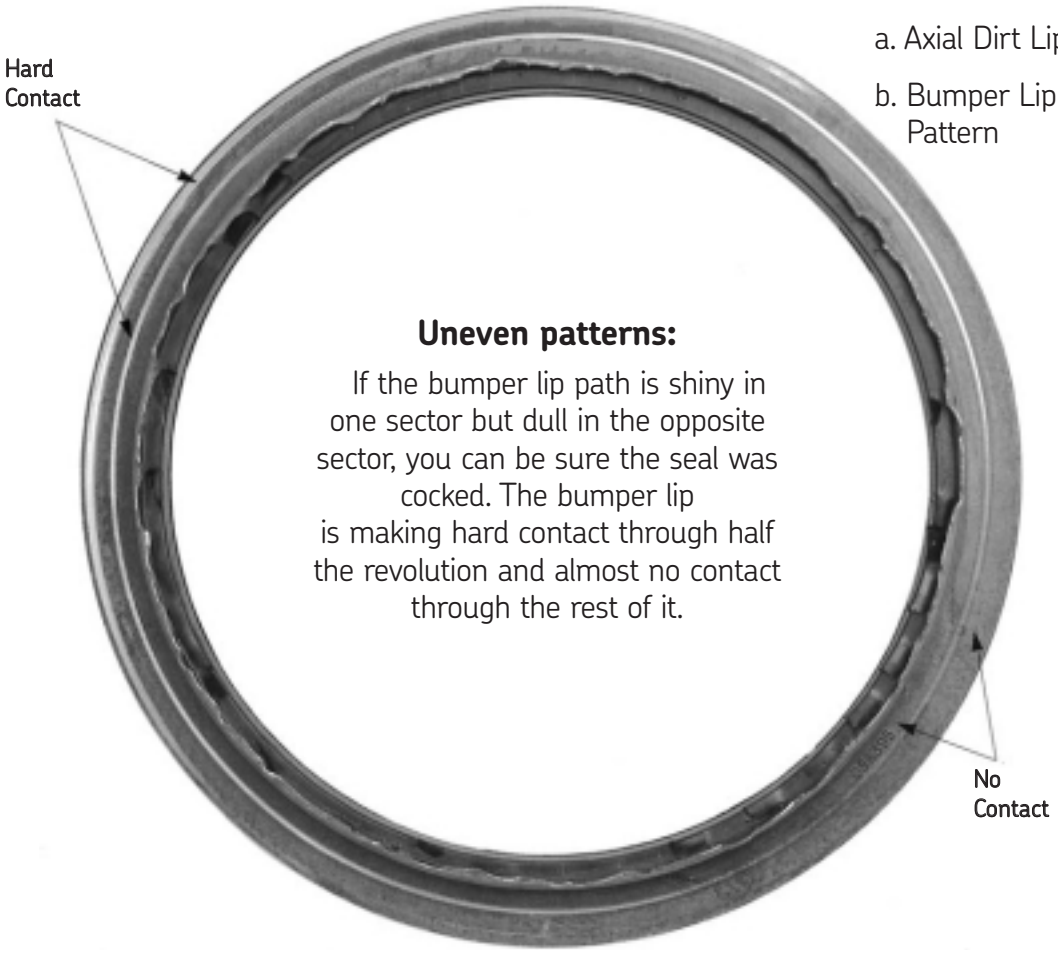
(fig. 4)



(fig. 5)

a. Axial Dirt Lip Pattern

b. Bumper Lip Wear Pattern



Uneven patterns:

If the bumper lip path is shiny in one sector but dull in the opposite sector, you can be sure the seal was cocked. The bumper lip is making hard contact through half the revolution and almost no contact through the rest of it.

CHAPTER 8 REVIEW

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any of the questions. This learning technique assures more than four times the normal retention rate for even this technical subject.

1. An alternating pattern of smooth and marked areas on the O.D. indicates that the seal was probably _____.
   - ❑ a. pressed into an out-of-round, over-size bore
   - ❑ b. cocked during installation
   - ❑ c. flattened by normal wear
   - ❑ d. misaligned

1. A

2. If a seal is cocked, it should be _____.
   - ❑ a. replaced
   - ❑ b. straightened
   - ❑ c. ignored
   - ❑ d. lubricated

2. A

3. Improper wear can cause a shaft to leak as a result of _____.
   - ❑ a. excessive STBM
   - ❑ b. excessive pressure
   - ❑ c. a cocked seal
   - ❑ d. all of the above

3. D

4. Pressure-caused seal failures may be corrected by _____.
   - ❑ a. opening air vents which may be plugged with dirt or paint
   - ❑ b. straightening the seal
   - ❑ c. reducing operating temperature
   - ❑ d. all of the above

4. A

5. If the seal lip is hardened and brittle with many cracks in its surface, _____ is probably the cause.
   - ❑ a. pressure
   - ❑ b. eccentricity
   - ❑ c. overheating
   - ❑ d. a cocked seal

5. C

6. Disulfide additives _____.
   - ❑ a. give lubricants anti-wear properties
   - ❑ b. can harden the sealing element
   - ❑ c. both of the above
   - ❑ d. neither of the above

6. C

7. Many seal failures can be traced back to the condition of the shaft or bore, or to poor installation.
   - ❑ True ❑ False

7. T

8. The first surface to check for wear patterns or markings is the inside diameter (I.D.) of the seal.
   - ❑ True ❑ False

8. F

9. Improper installation can cause the seal to leak.
   - ❑ True ❑ False

9. T

10. If the lip of the seal wears away during normal operation, less lubrication is required by the seal.
    - ❑ True ❑ False

10. F

11. If a leaking seal has a wide wear band on one side and a narrow band on the other, high STBM can be suspected.
    - ❑ True ❑ False

11. T

12. Heavy friction caused by excess pressure will eventually force the garter spring through the lip.
    - ❑ True ❑ False

12. T

13. If a sealing lip is hardened and brittle with cracks in the surface, the cause is probably excessive temperature.
    - ❑ True ❑ False

13. T

14. Chemicals that are used to improve a lubricant's performance will not spoil a seal.
    - ❑ True ❑ False

14. F

15. A small cut or nick on the sealing lip has no damaging effect on a good seal.
    - ❑ True ❑ False

15. F

NOTES

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